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FINAL REPORT

OF THE

NATIONAL WATERWAYS COMMISSION

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IN THE SENATE OF THE UNITED STATES,
March 25, 1912.

Ordered, That there be printed 1,000 copies of the Final Report of the United States National Waterways Commission, with Appendices thereto.

Attest:

CHAS. G. BENNETT,
Secretary.

By H. M. ROSE,
Assistant Secretary.

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FINAL REPORT OF THE UNITED STATES NATIONAL WATERWAYS COMMISSION.

The United States National Waterways Commission, having concluded its investigation of questions relating to water transportation and the improvement of waterways, herewith presents to the Congress its final report, as required by the river and harbor act of March 3, 1909, creating the commission. The conclusions and recommendations here presented supplement those submitted in the preliminary report of the commission, filed with Congress in January, 1910, and attached hereto as Appendix I, and also relate to the various subjects which were later referred to the commission by the river and harbor act of February 27, 1911. In the preparation of this report valuable assistance has been rendered by Mr. E. O. Merchant, expert for the commission, and Mr. G. W. Mooney, as well as by the corps of engineers and several officials of the Forest Service and Geological Survey.

This report presents the unanimous conclusions and recommendations of all the members of the commission on the following subjects:

1. The advisability of the Federal Government constructing the proposed canal connecting Lake Erie with the Ohio River near Pittsburgh, the expense of which is to be borne by the local interests affected; the feasibility of constructing an artificial waterway from Lake Erie to Lake Michigan by the Maumee River or other suitable route; and the feasibility of constructing a canal from the Anacostia River at some point near the District of Columbia boundary line to Chesapeake Bay.
2. Further legislation for protecting waterways against railway competition and for establishing more amicable relations between the two agencies of transportation.
3. Desirable legislation for the control of public terminals.
4. The practicability of impounding reservoirs for flood prevention and aiding navigation.
5. The influence of forestation upon the navigability of streams and the most salutary policy for the prevention of erosion.
6. Desirable legislation for the development and control of water power both in navigable streams and on the public domain.

Several articles containing information relating to the subjects investigated have been prepared for the commission and are printed as appendices to this report, but the views expressed therein are to be regarded as having neither the approval nor disapproval of the commission.

In addition to the preliminary and final reports submitted to Congress, the commission has also had printed for limited distribution some 22 documents relating to various phases of this subject, several of which are the reports of American consuls on the railways and

waterways of foreign countries. They furnish data of great value, especially to students of transportation problems, and present a considerable amount of information and important statistics never before published in this country.

PRESENT STATUS OF RIVER COMMERCE.

The commission in its preliminary report referred to the decline in water transportation on many of our rivers, especially on the Mississippi and most of its tributaries. In order to determine whether any noticeable change in conditions has occurred since the filing of that report with Congress, the commission has recently obtained from the Chief of Engineers reports from 44 district officers, showing the present status of river commerce on the streams under their supervision, In a majority of cases the reports indicate that the traffic has remained practically stationary since 1909. In some cases it has increased and in others it has declined, but there seems to be no evidence that there is a general trend in either direction. On the whole, traffic has shown the greatest increase on those rivers emptying into the Atlantic Ocean which are large enough to accommodate coastwise or foreign vessels. But these streams are estuaries or arms of the sea and hardly comparable with inland rivers. Some of the short tidal creeks along the coast of New Jersey and Delaware have also shown considerable improvement, due to the increase in farm products, which find a ready market in the large cities near by. On the Tennessee below Riverton and on the Cumberland below Nashville there has been a noticeable increase in traffic, while in other sections of these rivers traffic has declined. The fluctuations in traffic on the Tennessee are due largely to the increase or decrease in the cutting of timber. On the Cumberland about 42 per cent of the increase is composed of grain, live stock, tobacco, and general merchandise, and about 58 per cent of timber products and other low grades of freight. In the South there has been a steady growth of traffic from New Orleans out through the Passes. Since the opening of the Plaquemine Lock there has also been a large increase in traffic, particularly in sugar cane and sugar products, between Mississippi River points and the Bayou Teche country. In the far West there are a number of streams on which traffic has shown a very material increase, owing to the settlement of new country. This increase has been most noticeable on the Columbia River above Wenatchee in Washington and on the Coos in Oregon. On Petaluma Creek in California there has been a 30 per cent increase in traffic during the last year. This increase has been in general merchandise and farm products.

The most noticeable decline of river traffic during the last few years is found on the section of the Mississippi River from St. Paul to the mouth of the Missouri. In 1907 the total traffic was 3,919,440 tons, in 1910 it was only 1,836,035 tons, and in 1911, 2,081,506 tons. The decrease is most pronounced in lumber and saw logs. There has also been a steady decline in miscellaneous freight. On a number of small streams in the South the traffic which is composed almost entirely of lumber has also declined owing to the depletion of forests.

On several rivers there are indications of a greater interest in water transportation which may lead to some increase in traffic. During

the past year a new passenger and freight line has been operating on the Hudson River between New York and Albany. All the Hudson River lines are reported as doing a large business. On the Illinois River a new boat line from La Salle to New Orleans is being promoted. The city council of Peoria has just passed an ordinance providing for a vote by the citizens on a bond issue of $50,000, to improve the river front for a boat landing. During the year 1910 the Kansas City-Missouri River Navigation Co., with a cash capital of $1,200,000, raised by popular subscription, was organized, and has three boats ready for service as soon as navigation season opens in 1912. The company has completed at East St. Louis a warehouse equipped with modern electric freight-handling machinery, and has constructed at Kansas City a freight wharf costing $24,000. A storage warehouse is also under construction, which will be equipped with electric loading and unloading apparatus. During the year 1910 the Mississippi Valley Transportation Co. was organized at St. Louis. In June, 1911, this company reestablished the barge service between St. Louis and New Orleans, which was discontinued in 1903. The total receipts and shipments of this company at St. Louis for the remainder of the season were 11,130 tons. A new company, the St. Louis Gulf Steel Barge Line, is now being formed at St. Louis to acquire the plant of the Mississippi Valley Transportation Co., and intends to enlarge the equipment and to maintain regular barge service between St. Louis and New Orleans.

The reports indicate that an increasing interest in water transportation is also being shown along the Ohio River, and the establishment of a new line of steel boats and barges is being considered. During the year 1911 the American Bridge Co., whose works are located at Ambridge, about 15 miles below Pittsburgh, constructed a large number of steel barges, scows, and other steel water craft, most of which have been used by steel producing concerns in the Pittsburgh district for the transportation of steel products to lower Mississippi River points. The demand for steel barges which this company manufactures is increasing. The Crucible Steel Co. of America is now practically ready to commence transporting its coal by water from the sixth pool in the Monongahela River to its mills and factories at Pittsburgh and at Midland, 36 miles below. This coal was formerly obtained entirely by rail. This company expects to transport by river about 1,000,000 tons of coal annually, and also to transport its pig iron and steel products by water to lower river ports.

I.

Proposed Artificial Waterways.

THE LAKE ERIE AND OHIO RIVER CANAL.

By section 4 of the river and harbor act of February 27, 1911, the National Waterways Commission was authorized to investigate and report upon the advisability and feasibility of a canal connecting the Ohio River at a point near Pittsburgh with Lake Erie.

In April, 1911, several members of the commission visited Pittsburgh, held hearings and inspected the route of the proposed canal. At the request of the commission a report was prepared by Lieut.

Col. H. C. Newcomer, of the Corps of Engineers, containing much valuable information relative to this project. This is published in National Waterways Commission Document No. 21.

Careful surveys were made of this canal in 1895–96 and again in 1905, as a result of which the most feasible route, the approximate cost and other details have been ascertained. After the survey of 1905 a private canal company was formed, which secured charters from the States of Ohio and Pennsylvania and also from the Federal Government, intending to construct the canal as a private enterprise. The route selected for the canal, as a result of these surveys, leaves the Ohio River just above Dam No. 6 and proceeds by the Beaver and Mahoning Rivers to Niles, Ohio, a distance of 50.5 miles. This half of the route would be through canalized rivers. According to the plans of the engineers, the rise of 177 feet on this stretch can be overcome by 12 locks, each having a length of 360 feet, a width of 56 feet, and a depth over the lock sills of 12 feet. From Niles it is planned to construct the canal proper up the Mosquito Valley to the summit level, a distance of 8.5 miles with a rise of 55 feet to be overcome by 3 locks. The length of the summit level to Jefferson, Ohio, is 31 miles. For a part of this distance the plan is to construct an artificial lake which will serve at the same time as a reservoir for impounding part of the water supply needed for lockages. From the summit level at Jefferson, Ohio, the canal descends for the remaining distance of 13 miles through Indian Creek Valley to Lake Erie. The fall of 327 feet can be accomplished by means of 15 locks. The total length of the proposed canal is 103 miles, the total elevation overcome 559 feet, and the number of locks 30. The minimum depth decided upon is 13 feet, with 12 feet over lock sills. The project presents no serious engineering difficulties and there is assurance that an adequate water supply can be obtained at a reasonable cost.

The question to which the commission has given special consideration is whether the benefits from the construction of this waterway will be commensurate with the cost. The surveys made in 1905 fixed the total cost at $53,000,000. It is generally conceded now that this figure is somewhat too low, that $60,000,000 would be a more correct estimate. The factors which determine how much traffic can be reasonably expected to make use of this canal, if it is built, are on the whole favorable. It must be conceded that there is not in the whole United States a region offering greater traffic possibilities, especially in coarse, bulky freights such as would naturally go by water. In the territory between the Great Lakes and the Ohio River which this canal will traverse there is moved annually more than 50,000,000 tons of iron ore, coal, and coke, the iron ore being transported from the Lake Erie ports to the Mahoning Valley and Pittsburgh districts, and the coal and coke being carried in the opposite direction.

The main question to be considered in reaching a conclusion as to the feasibility of the proposed canal is what part of this traffic it can reasonably be expected to obtain in competition with the railways now operating in the same territory. The calculations made in 1905 give 3,000,000 tons as the probable traffic for the first year of operation, 22,500,000 for the fifth year, and 38,000,000 for the tenth year. There are a number of considerations which would indicate that these estimates are probably too high. In order to successfully compete

with the railways the canal must offer much cheaper transportation, except when there is an excess of traffic. This is due to the fact, as set forth in the preliminary report of the commission, that water transportation has certain natural disadvantages which lessen its convenience and reliability, and cause shippers to patronize the railway in preference, unless the water route offers sufficient inducement in cheaper transportation. The cost of transportation on the proposed canal is estimated at 1.58 mills per ton-mile, which, with the tolls proposed to be charged, would make the total cost about 3 mills per ton-mile. This would undoubtedly give the canal the required advantage over the competing railways if the present rates, which are generally considered to be high, amounting to about 8.5 mills per ton mile for iron ore and 6.8 mills per ton-mile for coal, were maintained after the canal was opened. It may confidently be expected, however, that the railroads will make substantial reductions from the present high rates whenever they are not operating to their full capacity, in an effort to keep traffic from being diverted to the waterway, and every reduction in their rates will lessen the advantages of the canal.

Some idea of the point below which the railroads could not profitably reduce their rates is shown by the fact that the cost of shipping ore on the Bessemer & Lake Erie Railroad, which is owned by the United States Steel Corporation and operated as a bulk freight road from Pittsburgh to Conneaut on the Lake, is stated to be about 2.8 mills per ton-mile, and the cost of hauling coal in full train loads on the Pittsburgh & Lake Erie Railroad, which the canal would parallel for most of its length, according to estimates made by Frank Lyon, attorney for the Interstate Commerce Commission, is less than 2 mills per ton-mile.

Several cases involving the fairness of these coal rates from the Pittsburgh district to the Lake Erie ports have recently been considered by the Interstate Commerce Commission and reductions amounting to 10 cents a ton ordered. The complaint investigated was that these rates were unreasonably high in comparison with the West Virginia coal rates, some of which average less than 3 mills per ton-mile.

The railways competing with the proposed canal will doubtless be restrained from making excessive reductions in their rates by the provision of the Mann-Elkins Act of 1910, which prohibits railroads lowering their rates in competition with a waterway from raising them again until after hearing by the Interstate Commerce Commission. This provision was inserted in accordance with the recommendation of the National Waterways Commission in its preliminary report, the purpose of which was to prevent the elimination of water competition by unfair means.

It is the opinion of the commission that the amount of coal which it is expected the proposed canal would carry has been overestimated. The coal deposits in the Monongahela Basin near to the river are becoming depleted so that it will be more expensive in the future to bring to the river the coal that is to be shipped in barges. This would make it more economical, as well as convenient, to patronize a railroad whose tracks reach directly to the mine. Furthermore, some of the coal lands most favorably situated for shipment of their output by water are owned or controlled by persons or corporations affiliated with railroad interests. Some allowance should also be

made in the estimates of both the prospective iron ore and coal traffic of the canal for the fact that many of the large iron and steel industries using these raw materials are more or less affiliated with the railroad interests which are the largest purchasers of their manufactured products.

To what extent these factors and the natural disadvantages peculiar to waterways will reduce the amount of traffic which the canal might otherwise obtain can not be accurately determined. Even with an annual average traffic of 10,000,000 tons it would about pay expenses and be of great commercial benefit to the localities which it would serve. Furthermore, the traffic between Pittsburgh and the Lake Erie ports is increasing rapidly and no doubt will soon require additional transportation facilities. It is a question how far the railroads now handling this traffic can increase their capacity because of the difficulty of enlarging their terminals, even at enormous cost.

The communities interested in this canal propose to bond themselves in order to raise the money for the cost of construction, and have already obtained the legislation necessary for such bond issues. They ask that the work be carried out under the direction of the Secretary of War and the Corps of Engineers, and that the Federal Government construct the harbor in Lake Erie and make the improvements necessary in the rivers of the Pittsburgh district.

In view of the great benefits which would result from the construction of this waterway, the Commission believes that the Federal Government is justified in cooperating with the localities which are to furnish the funds to the extent of building the approaches to the canal and of lending them the Army engineers to perform the engineering work necessary for its construction. The commission accordingly recommends that when $10,000,000 is available in cash, and bonds to the amount of $50,000,000, or as much more as is necessary in the opinion of the Secretary of War to insure its completion, have been authorized and the legality of such bonds has been certified by competent legal authority, he shall direct the Chief of Engineers to detail without charge for services such officers from the Corps of Engineers as he shall deem necessary to perform the engineering work necessary for the construction of the proposed canal. The commission further recommends that when the work of constructing the canal has actually begun Congress, if satisfied that it will be completed, shall appropriate the funds necessary for an adequate harbor in Indian Creek at the Lake Erie end and for the necessary improvement of the Ohio River in the Pittsburgh district, the same to be completed by the time the canal shall be ready for operation, but the Government should not be required to purchase any land in making these improvements.

The plan of cooperation here proposed is intended to leave the canal essentially a local enterprise, and the above recommendations for the cooperation of the Federal Government in constructing this waterway are not to be construed as committing or obligating the Government, now or at any future time, to assume any financial responsibility whatever in any way related to its construction, maintenance, or operation.

LAKE ERIE–LAKE MICHIGAN CANAL.

The second canal project which the commission, under the act of February 27, 1911, was authorized to investigate and report to Congress upon, is the proposed canal from Lake Erie, by way of the Maumee River and Fort Wayne, or other direct and feasible route, to the southerly end of Lake Michigan.

In November, 1911, several members of the commission went over the route of this canal from Toledo as far as Fort Wayne, at which place hearings were held. The commission has also requested and received from the Chief of Engineers, United States Army, a report on this project prepared by Col. George A. Zinn, which contains much valuable information. This is printed in National Waterways Commission Document No. 21.

One purpose of this canal is to obviate the long detour around the Michigan Peninsula, thus affording a more direct water route from Chicago to New York. The present route would be shortened about 400 miles, the distance from Chicago to Buffalo via the Straits of Mackinac being 892 miles and via the proposed canal 490 miles.

Various routes have been proposed for a canal between Lake Erie and Lake Michigan. The most feasible one, from information now available, would proceed from Toledo up the Maumee River as far as Fort Wayne, and from this point to Lake Michigan by an artificial waterway. The Maumee River has been examined by Col. Millis, Corps of Engineers, and reported to be capable of improvement at a reasonable cost. A number of routes from Fort Wayne to Lake Michigan have been suggested, the respective merits of which the commission is not authorized nor competent to pass upon. The selection of the best one is largely an engineering problem which can only be determined after a more detailed survey than has yet been made.

Two different types of canals have been urged before the commission, the first a ship canal with a depth of 24 feet, the second a barge canal with a depth not exceeding 16 feet. The main arguments presented for the former type were that a ship canal would be necessary in order to compete with the Georgian Bay Ship Canal, the construction of which is contemplated by Canada, and, second, that it would allow the ordinary lake steamer to pass through without breaking bulk, thus reducing the cost of transportation.

In support of the barge canal it was urged that a considerable proportion of the traffic of the canal in all probability would consist of through freight between Chicago and New York, and that it would not be necessary to have the dimensions of the proposed waterway materially greater than those of the Erie Canal. Furthermore, a type of barge of about 2,000 tons capacity has been especially designed to pass through the proposed canal as well as the Erie Canal and at the same time safely navigate the Lakes. It was stated to the commission that vessels of much the same type are now being used on the Great Lakes and the Welland Canal for the Montreal trade. If such barges prove successful, there would be no necessity of transshipment en route.

After careful consideration of the merits of the two projects the commission is of the opinion that the 24-foot canal should not be considered. The cost of construction, together with the difficulty of

securing an adequate water supply, makes such a project impracticable. Moreover, if it were constructed, the commission is of the opinion that large lake steamers would choose the longer lake route by way of the Straits of Mackinac in preference to the slow and tedious passage through the proposed canal. The general conclusions of the commission regarding the advisability of constructing canals for deep-draft vessels are stated in its preliminary report. (See pp. 12-15.)

In view of the fact that the proposed barge canal is intended as a connecting link in a water route between Chicago and New York, in which the enlarged Erie Canal will also form a section, the commission believes that there would be no material advantage in making its dimensions larger than those of the Erie Canal, while the extra depth would considerably increase the cost of construction. For this reason the commission is of the opinion that 14 feet rather than 16 feet is the more practical depth for this waterway.

The commission has considered especially the feasibility of the proposed canal from the standpoint of prospective traffic. According to the evidence presented, the main sources of business for the canal would be (1) the through traffic between Chicago and New York, Boston, and other North Atlantic seaports, in competition with the trunk-line railway systems; (2) such traffic as it would divert from the present lake route; (3) the local traffic of that section of Ohio and Indiana through which the canal would pass.

Under the present conditions an enormous freight traffic is annually transported by rail through northern Indiana. In 1910, 116,097,749 tons of freight were moved within the State of Indiana, one-half of which crossed the western line of the State within 20 miles of Lake Michigan, and traversed the territory through which the canal would pass. By providing a more direct water route between Chicago and New York, the proposed canal would supplement these rail lines in handling this heavy through traffic and thereby afford relief in periods of congestion. It is expected by those interested in this project that the Chicago-New York traffic would form the main business of the canal.

Grain is one of the commodities at present carried in large quantities by rail, which is peculiarly adapted to water transportation. In 1911, according to the report of the Chicago Board of Trade, the railways running east from Chicago carried flour, 2,580,945 barrels; wheat, 7,112,700 bushels; corn, 38,645,075 bushels; oats, 64,129,300 bushels; barley, 5,697,400 bushels, representing approximately 2,684,278 tons. In order to divert any of this traffic from the railways, the water route, of which the proposed canal would form a link, must offer better facilities and cheaper transportation than the present lake route, with which it would also compete.

The canal is expected to divert some portion of the traffic now being carried on the Great Lakes. Because of its location, it would not secure any of the large iron-ore traffic transported between the Lake Superior and the Lake Erie ports, but it might obtain some of the westbound coal destined for Chicago and points along the canal route. It is thought that it would also divert some of the grain traffic from Chicago to New York that is now handled by lake vessels, since the season of navigation of the canal would be considerably longer than that of the Straits of Mackinac and St. Marys

River, and canal barges of the type referred to could reach New York without transshipment and at times when grain elevators along the route were congested.

The third source of traffic for the canal would be the local business furnished by the agricultural and industrial regions through which it would pass. The Maumee Valley, both in Ohio and Indiana, is one of the richest farming regions in the United States. The lack of adequate transportation facilities and the delay in transit, even in dull seasons when the railroads are not operating at their full capacity, are alleged to be a serious hindrance to the marketing of these farm products. A grain dealer at Fort Wayne stated to the commission that he had kept a record of 45 carloads of oats shipped to Buffalo in 1911. The average number of days consumed in transit by these cars was 15, several taking more than a month. It also appears from evidence presented to the commission that there is a frequent shortage of elevator facilities for storing grain at Toledo and other centers, the inconvenience of which could be avoided by the through water route. The railroad rates on grain from Indiana to eastern points are stated to be higher than the corresponding rates from Chicago to the same points. This is due to the fact that 95 per cent of the grain traffic is shipped east from Chicago under what are known as proportional rates. Grain brought to Chicago under the stoppage-in-transit privilege may be stored in elevators or milled and then be reshipped to destination under a through bill of lading. In such cases the rate from Chicago eastward is considered a part of the total charge from point of origin to point of destination and is much lower than the published rates. The above facts indicate that considerable agricultural produce, especially grain, might be expected to make use of the proposed canal if constructed.

There are also a number of rapidly growing manufacturing centers along the probable route of the canal, which require cheap raw materials and transportation rates which will enable them to reach the markets with their finished products. Fort Wayne, on the Maumee River, is the third manufacturing city of Indiana, and second in point of growth. The value of her products in 1909 was $23,687,000, an increase of 69 per cent over 1904. If the proposed canal passed through Elkhart, South Bend, and the other important manufacturing towns of northwestern Indiana, one of the various routes suggested, they might also be expected to contribute considerable local traffic.

In view of the importance of this project in furnishing additional means of transportation in a locality where it is much needed for the benefit of through traffic, as well as for marketing farm products and for taking care of the needs of the rapidly growing manufacturing centers through which it would pass, the commission recommends that a survey be made by the Corps of Engineers, United States Army, to determine what is the most feasible route, the probable cost of construction, and its traffic possibilities. In selecting the best route not only engineering difficulties should be considered but also the best location of the canal with reference to its use both for local purposes and for through traffic. For carrying out this survey, the commission recommends that a sum not to exceed $15,000 be appropriated by Congress.

Projects such as this, which constitute connecting links in important routes, will possibly at some time, as the country develops, become worthy of adoption by the Government. Whether the time has yet arrived when the construction of the proposed canal would result in benefits commensurate with the cost can only be determined after further investigation, in which the survey recommended would logically be the first step. A question that should also receive careful consideration is whether the communities especially benefited by this project should not participate in the cost.

ANACOSTIA AND CHESAPEAKE CANAL.

By the act of February 27, 1911, the National Waterways Commission was also authorized to investigate and report to Congress upon the proposed canal to connect the Anacostia River at some point near the District of Columbia boundary line with the Chesapeake Bay or some tributary thereof.

The original project, investigated in 1828, was to construct a shallow-draft canal as a continuation of the Cheaspeake and Ohio Canal, which was then contemplated. The purpose was to obtain a water route from Baltimore to the Ohio and the West. Later projects have had in view a ship canal to shorten the distance from Washington to the Chesapeake Bay and Baltimore. The main argument in support of such a canal at the present time appears to be the substantial saving in distance which it would afford. The distance from Washington to Chesapeake Bay by the Potomac River is 110 miles, while by the most feasible canal route the distance would be 34 miles. The distance from Washington to Baltimore by the Potomac River and Chesapeake Bay is 210 miles, while by the proposed canal route the distance would be 79 miles. If a sea level ship canal were constructed, cuts of from 180 to 200 feet would be necessary, depending upon the route selected. Such a canal would be very costly, and only warranted if great traffic possibilities existed. A lock canal of large dimensions is out of the question because of the lack of an adequate water supply. The combined minimum discharge of the Anacostia and Patuxent Rivers, the only available sources of water supply, is reported by the engineer of this district to be entirely inadequate. Further, there would be little time saved in navigating such a canal in preference to the present roundabout route, since the speed at which a large boat could proceed would not average more than 4 miles an hour, while on the open river and bay it could average 10 or 12 miles.

Investigation has failed to disclose the sources of any considerable traffic for the proposed canal. It would not form a link in any existing water route and could only obtain such traffic as passes between Baltimore and Washington. None of the coal reaching Georgetown by way of the Cheaspeake and Ohio Canal is destined for Baltimore. Some coal comes from Baltimore to Washington by rail, but this is also carried to Baltimore from the coal mines by rail. None of it could be expected to use the proposed canal, especially since the distance by rail between the two cities is 40 miles, as compared with 79 miles by the proposed water route. There also appears to be little or no prospective local traffic along the route of the canal in Maryland.

The present boat lines operating between Washington and Baltimore would not use the canal, inasmuch as they depend for their business to a large extent upon the passenger and freight traffic to intermediate points along the present route.

What changes may come in the channels of trade in the future can not be accurately foreseen. It is conceivable that the development of more extensive lines of water transportation might make this project a connecting link of considerable importance; but in view of present conditions the commission can not recommend its adoption by the Government at this time.

II.

Desirable Legislation for the Protection of Water Transportation and for Establishing Greater Cooperation Between Railways and Waterways.

The commission in its preliminary report called attention to the fact that the decline of water transportation in the United States was due largely to the competition of railways, and pointed out that railways had certain natural advantages which caused them to be preferred by shippers as a means of transportation. Some of these advantages are the greater accessibility to all points, the readier exchange of traffic from one road to another on through rates and through bills of lading, which has been possible since the adoption of a standard gauge for all the railroads of the United States, the superior terminal facilities, and in most instances the greater speed and reliability of service.

It was also pointed out in the preliminary report of the commission that the railways had secured a further advantage by rate cutting and other discriminatory practices which were not prohibited by law. Since the filing of this report with Congress this latter advantage has been to some extent removed by the amendments to the interstate commerce act made by the Mann-Elkins law of 1910. Section 4 of the act of 1887 has been strengthened so that railways can not charge less for a longer than for a shorter haul, except with the consent of the Interstate Commerce Commission, althought the extent of the commission's power in this respect is still somewhat uncertain, owing to the reversal of its decision in the Intermountain Rate cases by the Commerce Court. A provision has also been added, following the suggestion of the National Waterways Commission, which prohibits railways that have lowered their rates in competition with waterways from raising them again, unless after hearing by the Interstate Commerce Commission it is shown that the proposed increase rests upon changed conditions other than the elimination of water transportation. This new legislation will, it is hoped, give greater confidence to capital in investing in the business of water transportation. But, as pointed out in the preliminary report, the rehabilitation of water-borne traffic will not be complete unless there is greater cooperation between railways and waterways so that they will exchange traffic, just as the railways now do with one another on joint rates and through bills of lading. Unless this exchange of traffic can be accomplished the business of the waterways must necessarily be confined to their banks. After careful consideration the commission

believes that the best means of establishing greater cooperation between the two agencies of transportation is to increase the power of the Interstate Commerce Commission over water carriers.

Power of commission over water carriers.—When the act to regulate interstate commerce was passed in 1887, boat lines were intentionally exempted from the scope of the law, because it was thought that if they were free from any governmental restraint they would be better able to compete with railways and would be more effective as regulators of railway rates.

The only power the Interstate Commerce Commission has over water lines is derived in the first instance from section 1 of the amended act of 1887:

The provisions of this act shall apply * * * to any common carrier or carriers engaged in the transportation of passengers or property wholly by railroad (or partly by railroad and partly by water when both are used under a common control, management, or arrangement for a continuous carriage or shipment), etc.

This clause has been interpreted to mean that where a boat line, whether owned and operated as a part of a railway system or operated independently, voluntarily enters into prorating arrangements with a railroad the joint tariffs are subject to the control of the Interstate Commerce Commission. If a boat line, no matter how owned or controlled, does not make any joint rates with a railroad, it would not come within the jurisdiction of the Interstate Commerce Commission. This is clearly set forth by section 15, which, as amended in 1910, contains the supplementary provision:

Nor shall the commission have the right to establish any route, classification, rate, fare, or charge when the transportation is wholly by water.

The extent of the power of the Interstate Commerce Commission over water carriers which prorate with the railroads depends upon whether by prorating they become common carriers within the meaning of the law and subject to all its provisions, or whether they are only subject to the law in respect to that portion of their business which is carried on joint rates with a railway. This question has not yet been adjudicated. The Supreme Court in the Goodrich Transit and White Star Line cases has just decided that the commission has power to require reports and prescribe methods of bookkeeping.

The Interstate Commerce Commission has no general power to compel prorating arrangements between boat lines and railroads. The fifteenth section of the interstate commerce act, as amended in 1910, invests the commission with the power to establish through routes and joint maximum rates between carriers subject to its control whenever the carriers refuse or neglect to establish such facilities voluntarily. This clause further states that this provision shall apply when one of the connecting carriers is a water line. Hence it appears that the Interstate Commerce Commission can, if it chooses, establish through routes and compel joint rates between boat lines and railroads if the boat line has placed itself under its jurisdiction, but not otherwise. Furthermore, the commission has no power to compel railroads to make physical connection with boat lines, even where such connection is possible and desirable for the formation of a through route.

Need of further legislation.—There is great need of increasing the power of the Interstate Commerce Commission over joint rates and

through routes between rail and water lines, so that it may form such routes and compel such joint rates wherever, in its opinion, it is for the public interest. The commission should also be given power to compel physical connection between railways and waterways wherever possible and necessary for the formation of through routes. Unless this power is granted, the cost and inconvenience of transferring freight by truck from one terminal to the other will offer a serious obstacle to the development of exchange traffic. It is also desirable that the commission should have power to compel railways to charge less than the local rates to all lake, river, and sea ports on through traffic to be exchanged with boat lines engaged in domestic trade, unless prorating arrangements already exist. Such reduced rates are now voluntarily granted in some cases, especially along the Great Lakes. Where reductions are not granted, the high local rate charged by a railroad on transfer traffic so largely offsets the lower water rate that there is no advantage in shipping by the combination rail and water route.

The commission believes that the protection afforded the waterways by section 4 of the act to regulate interstate commerce as amended in 1910 is not sufficient for the preservation and the growth of water transportation. The lack of adequate regulations makes it possible for the railways to effectually control or to crush out water competition through their ownership and control of boat lines. It is a well-known fact that the trunk-line railways, through their control over terminals at Buffalo and their ownership of steamship companies on the Great Lakes, have been able to dominate the lake and rail package-freight business between New York and Chicago and also to a considerable extent the grain traffic. On the business thus controlled the water rates have risen, while on the coal, iron, and grain traffic not controlled by the railways the water rates have steadily declined. In like manner the New York, New Haven & Hartford Railroad practically dominates water transportation on Long Island Sound by reason of its ownership of the New England Navigation Co. Independent companies have been unable to compete successfully, owing to the advantage which their railway-owned competitor enjoys. The steamship companies plying between the North Atlantic and Southern ports in the coastwise trade are likewise working in harmony with the connecting and competing railways by which they are owned or controlled, so that little, if any, active competition exists. Also on some rivers the railways have acquired control of packet lines.

While this rapidly increasing control of railways over water lines tends to bring about that harmony and cooperation between them which is necessary for the development of transfer traffic, it also has possibilities of harmful results which require regulation. Where the railways grant prorating arrangements to boat lines which they own or control, while denying the same privilege to competing independent lines, the latter are practically precluded from securing any transfer traffic, while on the local or port-to-port business they must meet the competition of the railway-owned boat lines, which are at liberty on this business to cut rates to any extent they choose. Under such conditions it is very difficult for independent lines to succeed, and the cases are numerous where they have been forced to retire from the field.

This situation calls for additional legislation not only to prevent the elimination of water competition by this means but also to protect the public against the raising of water rates which railway control over boat lines makes possible. Legislation to this end is as necessary for the preservation of water transportation as is the prohibition of rate cutting and other discriminatory practices, but it should not be of a character to discourage legitimate investment in the business of water transportation, even by railway companies. If the activities of boat lines are properly regulated in the interest of the public, the question of ownership or control will become of minor importance.

Recommendations.—The commission believes that the simplest and most effective means of securing these desired regulations is to give the Interstate Commerce Commission greater control over water lines, and accordingly recommends that every water carrier engaged in interstate commerce which is owned or controlled by a railroad, or in which a railroad is in any way interested, and also every independent water carrier which operates over a specified route with regular schedules, be placed under the control of the Interstate Commerce Commission and be made subject to the same rules and regulations now imposed upon railway corporations in so far as they are applicable. The commission should, however, be given broad discretionary power in enforcing the requirements of the law, particularly those relating to the filing and changing of rates, so that no unnecessary burdens will be imposed upon water transportation. The commission also recommends that the Interstate Commerce Commission be empowered to establish physical connection between the terminals of railways and boat lines where possible and desirable, and also to compel the charging of lower than the regular rates to river, lake, or sea ports when the traffic is to be exchanged with water carriers.

If water lines were made common carriers within the meaning of the law, the Interstate Commerce Commission would have power, under the present statutes, to establish through routes between rail and water lines and to require joint rates and through bills of lading. It would also have power to regulate the charges of water carriers and to require annual reports and other information by which to judge of the reasonableness of their charges.

III.

The Control of Water Terminals.

Undoubtedly the most essential requirement for the preservation and advancement of water transportation is the establishment of adequate terminals properly controlled. Under present conditions the advantage of cheaper transportation which the waterways afford is largely nullified by the lack of such terminals.

According to the report of the Commissioner of Corporations on water terminals, private interests control nearly all the available water front in this country, not only at the various seaports but also along the Great Lakes and the principal rivers. Only two ports in the United States, New Orleans and San Francisco, have established

a public control of terminals at all comparable with the municipal supervision existing at most European ports.

The above-mentioned report on water terminals also shows that a large proportion of the most available water frontage is owned or controlled by railway corporations. Through this ownership or control they practically dominate the terminal situation at most of our ports, and they have generally exercised their control in a manner adverse to water traffic. In many cases they hold large tracts of undeveloped frontage which they refuse to sell or lease, and which are needed for the construction of public docks. This railway control of terminals is one of the most serious obstacles to the development of water transportation, for the control of the terminal means practically the control of the route. An independent boat line has small chance of success where it is denied the use of docks and terminal facilities or is required to pay unreasonable charges for their use. The high terminal charges at many of our ports make it impossible for small boat lines to enter at all.

The commission believes that the proper solution of this terminal question is most vital to the future of water transportation. It is, however, more a local or State than a Federal problem. As pointed out in the preliminary report of the commission, there should be a proper division between the functions of the Federal Government and local communities in the improvement of waterways. The Federal Government should improve channels, while the municipalities should cooperate to the extent of providing adequate docks and terminals. It is absolutely essential for the growth of water transportation that every port, whether located on the seacoast or on some inland waterway, should have adequate public terminals, at which all boat lines can find accommodations at reasonable rates. Inasmuch as the indifference of communities to their responsibilities in this matter largely nullifies the benefits of expenditures by the Federal Government for channel improvements, the commission emphasizes the recommendation made in its preliminary report that further improvements in rivers and harbors be not made unless sufficient assurance is given that proper wharves, terminals, and other necessary adjuncts to navigation shall be furnished by municipal or private enterprise, and that the charges for their use shall be reasonable. It can not be too strongly urged that in many cases it is not the condition of channels so much as it is the lack of terminals that is retarding the development of water transportation.

Where water frontage necessary for the establishment of public terminals is held undeveloped by railway or other private interests, a special act of the legislature should be passed, empowering State or municipal officials to condemn such property for public use. This plan has already been followed in a few cases and should be more widely adopted. The proposal has sometimes been made that the Federal Government should condemn private property and establish public terminals along the rivers and in the harbors which it is improving in order that the benefits of such expenditures may not be nullified. The commission, however, would not recommend the adoption of such a policy unless it shall be found after a fair trial that the States and localities can not adequately solve the problem.

IV.

The Practicability of Storage Reservoirs for Flood Prevention and for Aiding Navigation.

By section 4 of the act of February 27, 1911, the National Waterways Commission was authorized to investigate and report to Congress upon the feasibility and advisability of impounding flood waters of rivers by storage reservoirs. Especial attention was directed to this subject by the introduction of bills in Congress relating to the flood situation at Pittsburgh.

Reservoirs have been employed at different times for storing a water supply for irrigation, for the improvement of navigation, for the development of water power, and to some extent for flood prevention. They generally combine several of these uses, but may be constructed primarily for a single purpose. In this report the commission confines itself to a discussion of the last three uses named with special emphasis upon navigation.

In recent years the construction of reservoirs for different purposes has been quite common in Europe. The largest system of artificial reservoirs is found in Russia at the headwaters of the Volga and Msta Rivers. It has been successfully used for aiding navigation and preventing floods. A larger number of reservoirs have been or are being constructed in Germany than in any other European country. The principal ones are situated on the tributaries of the Oder, Weser, and Rhine, and those completed are being operated with good results for aiding navigation, flood control, and power development.

Thus far in the United States no reservoir system, intended to be operated for several purposes, has been adopted, although a considerable number of reservoirs have been constructed for a particular use. In only one instance has the Federal Government constructed a system of reservoirs for aiding navigation. This system is located at the headwaters of the Mississippi River. The original project contemplated a system of 41 reservoirs, but thus far only 5 have been completed and put in operation, although a sixth one is now under construction. The reports of engineers in charge and of others who have studied the effects of these five reservoirs indicate that they have been successfully employed in aiding navigation, although they are of limited capacity and only control the run-off from about 11 per cent of the drainage area above St. Paul. They have increased the stage of the Mississippi River at St. Paul during dry seasons by an average maximum of 18 inches. During the unprecedented dry weather of 1910, when the rainfall in many sections of Minnesota was less than half the normal, these reservoirs supplied more than 2 feet of water at St. Paul, which in the month of August was 70.3 per cent of the total flow of the river.[1] During the summer of 1911 they were equally effective. The direct annual value of this reservoir system to present and prospective power enterprises has been estimated at $500,000, the cost of the system to June 30, 1910, being only $1,545,943.[2] These reservoirs, as shown by the reports, exercise little, if any, effect upon floods, inasmuch as their capacity is very limited and they are operated primarily for aiding navigation. In fact,

[1] See Appendix III, p. 175. [2] Annual Report, Chief of Engineers, 1910, Part I, p. 632.

" Flood protection. ✓
[illegible] II & IV

charges have been made that they were responsible for floods, but upon examination such charges are found to be without proof.

In operating reservoirs for the purpose of navigation, the plan is to fill them during the wet season and to retain the water thus stored until needed to reenforce the flow of the river during the summer months. In the case of the Mississippi River reservoirs, the water is not released until the stage of the river at St. Paul is reduced nearly to 3 feet, due allowance being made for the fact that approximately a month is required for the water released from the reservoirs to reach St. Paul.

In a few cases reservoirs have been constructed primarily for power development by private capital. Some of these are intended to store water during the night so that a constant flow can be maintained during the day, while others have been constructed to regulate the seasonal flow of streams. Perhaps the best example of the former is found on the Blackstone River, in Massachusetts and Rhode Island. By the use of dams this stream above the power plants has been turned into a series of pools, which fill during the night and are drawn down during the day. The best example of the use of reservoirs to regulate the seasonal flow of streams for power purposes is found at the head of the Androscoggin River, in Maine. The Rangeley Lakes have been dammed and an enormous artificial reservoir as large as any of the lakes is also being constructed by private capital, the purpose of which is to maintain a constant flow over the power turbines throughout the year. Coeur d'Alene Lake, at the head of Spokane River, in Idaho, is also being utilized in the same manner.

Where reservoirs are built and operated primarily for power purposes they are usually of too small capacity to be of much use for navigation or flood prevention, although they may afford incidental benefits of this kind.

In recent years the utilization of storage reservoirs to prevent floods has been strongly advocated in this country and their benefits for certain streams carefully studied, but as yet none has been con-constructed primarily for this purpose. In some cases, however, reservoirs intended for other purposes have incidentally been operated so as to aid in preventing floods. This has been especially true of the reservoir built for irrigation purposes at the headwaters of Salt River in Arizona.

A reservoir system intended for flood prevention should be more extensive than where intended primarily to benefit navigation or the development of water power. This is due to the fact that floods are caused by the combination of many factors and these combinations are never twice alike. A stream may exercise an important influence on the flood peak at one time and have little or no appreciable influence at another. For example, in the Ohio River flood of March 22, 1905, the upper Allegheny and its tributaries, the Clarion and French Creek were the principal contributors, while in the flood of March, 1907, they had little effect on the flood peak. The influence of a stream in a particular instance is not known until the flood is over. It depends upon the amount of precipitation in its watershed and upon various other factors which affect the time when its flood waters are emptied into the main stream. This makes it necessary to control a considerable proportion of the run-off on almost every important stream in a river basin in order to be sure of adequate protection.

It is perfectly possible to operate a reservoir system if its capacity is sufficient so as to benefit navigation, develop power, and prevent floods. But in such a case its utility for any one of these purposes is necessarily diminished. To obtain the maximum effectiveness for flood prevention, the reservoirs should be lowered as soon as possible after a heavy rain sufficiently to afford storage capacity to catch the water from the next storm. This means less power development and less benefit to navigation. It is quite possible that reservoirs operated solely for flood prevention would be found practically empty during the summer months when the water which had been released earlier was needed for increasing the flow of streams. If reservoirs are operated primarily for navigation they are filled during the rainy season, and the water is held until needed during the summer months. If, after they are filled, a heavy rain should come, they would not be in a position to catch and hold any of it, and, therefore, could exercise no influence upon the flood level.

A plan for avoiding this difficulty has been suggested by Mr. M. O. Leighton, of the Geological Survey.[1] A reservoir system intended for flood prevention and also for aiding navigation should have a twofold capacity: It should have permanent storage in order to keep the summer flow as uniform as possible, and, in addition, it should have an excess capacity equivalent to the maximum flood run-off in order to take care of the largest floods. Such a plan has been advocated by the water supply commission of New York State in the case of a proposed reservoir on the Genesee River. The proposed dam would be 152 feet in height. The first 32 feet of water would be held permanently or for very infrequent use. The next 45 feet of water would be held in storage until needed to compensate low-water conditions in dry seasons. The next 55 feet would be used for new power development and to increase the capacity of the power plants already established along the river. Of the remaining 20 feet of reservoir capacity 15 feet would be used for flood catchment, and 5 feet would be held in reserve for extreme floods. The water caught in flood periods would be released as soon as the condition of the river below permitted, to the point of permanent storage, leaving the reservoir ready for the next flood, while the water stored for navigation purposes would be held until the summer months.

A reservoir system, in order to be utilized simultaneously for flood prevention, aiding navigation, and power development, must be controlled or operated by some public authority.

There is practically a unanimity of opinion that reservoirs can accomplish the purpose for which they are intended, providing that they have sufficient capacity. The main criticism has always been that the cost of constructing such a system would be prohibitive. This criticism, however, becomes less applicable as the country develops and greater benefits can be obtained from the proper improvement and control of streams.

Thus far the improvement of rivers in this country, except in the arid regions, has been almost solely for the purpose of navigation. The other purposes have been almost entirely disregarded. The position of the Corps of Engineers who have supervision over river improvements has been that an increased depth of a stream for navigation could be secured much more cheaply by the use of dams,

[1] See Appendix II, p. 136.

diverting walls, and other devices than by constructing reservoirs at headwaters, and in this view the engineers have in general been right, particularly when it is recalled that the existing or prospective commerce on few of our streams has justified extensive expenditures for this purpose, and only on a comparatively few streams do suitable reservoir sites exist. When, however, the improvement of a stream is considered from the standpoint of all its beneficial uses, as well as the prevention of damage by floods, the policy of constructing reservoirs may become, in particular cases, more feasible. The combined benefits from flood prevention, from additional power development, and from a more uniform flow of the stream may warrant the adoption of a system of reservoirs which, if intended for any one of these purposes alone, would not be practicable.

The commission has given special consideration to the feasibility of constructing reservoirs on the tributaries of the Ohio River. From the information obtained it appears that such a plan has greater prospects of success here than in any other part of the United States. The damages caused by frequent floods in the Ohio Valley are enormous. In the second place, investigations show that a large number of unusually good reservoir sites exist on the principal tributaries. Thirdly, the Ohio and Monongahela Rivers have a larger traffic than any other rivers in the United States and the Government is now spending more than $60,000,000 to secure a 9-foot navigation from Pittsburgh to Cairo. It is quite possible that when the commerce of the Ohio becomes greater there may not be water enough during dry seasons to properly operate the locks which are being constructed. Such has already been the case on the Monongahela, where it has sometimes been found necessary to empty the upper pools in order to obtain sufficient water to make the lockages in the lower pools. Fourthly, the great industrial region around Pittsburgh would doubtless offer a profitable market for water power that might be generated in connection with the establishment of a reservoir system. Finally, because of extensive investigations, more is known about the reservoir possibilities of this river basin than of any other.

The plan of impounding reservoirs on the tributaries of the Ohio to prevent floods and improve navigation was pointed out by Mr. M. O. Leighton, in his report to the Inland Waterways Commission in 1908. Since that time the subject has been thoroughly investigated by the Pittsburgh Flood Commission, which will soon publish an exhaustive report. This commission, composed of prominent engineers, examined in detail 43 reservoir sites on the Allegheny, Monongahela, and their tributaries, with special reference to the prevention of damage from floods at Pittsburgh. They recommend the adoption of a system composed of 17 reservoirs, costing $21,672,000. The detailed estimates of their plan are shown by the following table:

	Allegheny.	Monongahela.	Combined.
Drainage area controlled:			
Square miles	8,023	2,159	10,182
Per cent of total drainage area	69.2	29.5	53.8
Total capacity, million cubic feet	42,178.5	17,302.9	59.481.4
Total cost of dams and appurtenances	$8,077,863	$3,101,131	$11,178,994
Total cost of land submerged [1]	$848.579	$238,470	$1,087,049
Total cost, including damages	$16,851,800	$4,820,300	$21,672,100

[1] 28,289 acres at an average price of $38 per acre.

With the construction of a wall along the low-lying portions of the river bank at Pittsburgh, the flood commission believes that this system would be sufficient to protect the city against all but the most severe floods. A larger system of 28 reservoirs, costing about $28,000,000, and a still larger one of 43 reservoirs, costing $34,000,000, have been outlined and suggested as alternatives.

The extent to which this system of reservoirs will benefit the navigation of the Monongahela, Allegheny, and Ohio Rivers depends upon the amount of water that can safely be retained in the reservoirs until needed for low-water assistance. The flood commission estimates that the equivalent of 50 per cent of the storage capacity of each reservoir could be retained for this purpose without impairing its efficiency for flood prevention. Col. Newcomer, of the Corps of Engineers, United States Army, after an examination of the report of the Pittsburgh Flood Commission, is of the opinion that the capacity of the system of 17 reservoirs which they recommend is not sufficient to prevent floods and at the same time afford much benefit to navigation. The difficulty of reaching a final conclusion on this point is due to the lack of complete and accurate statistics of rainfall and river discharge. The findings of the flood commission are, for this reason, based upon assumptions the accuracy of which it is difficult to determine. Mr. Leighton, however, suggests a plan of operating the reservoirs, by which the system of 17 could be effectively utilized both for flood prevention and for aiding navigation. His plan is that the reservoirs should be operated primarily for flood prevention from about November 1 to April 1, and entirely for aiding navigation from about April 1 to November 1. A study of past floods shows that 80 per cent occur between November 1 and April 1, and only 20 per cent in months from April to November. Furthermore, those occurring during the latter period are not as severe or as damaging. Therefore, Pittsburgh could well afford to remain subject to the occasional summer floods in view of the practically complete relief from the violent ones of winter and spring. After the 17 reservoirs have been constructed and operated for a sufficient length of time to demonstrate their effectiveness, additional reservoirs could be built if found necessary.

The communities interested in this project propose to raise the larger portion of the money required to carry it out by bond issues, and ask that the Federal Government, because of the benefit which will result to navigation, should cooperate with them by bearing a share of the expense, and by authorizing the Corps of Engineers to construct and operate this system of reservoirs. They assert that prompt action is necessary, or the most desirable reservoir sites which they have selected will be appropriated by private parties for the development of water power.

After careful consideration of the problem of utilizing storage reservoirs for flood prevention, the commission has arrived at the following conclusions:

1. As the country develops the necessity for controlling floods becomes of greater importance, both in respect to improved property in thickly populated districts and to valuable unimproved lands which are needed for agricultural or manufacturing purposes. Losses from floods are not confined alone to the destruction or damage of property, but also result from the inability to utilize large areas threatened

by floods. In the case of many streams the adoption of some means of flood prevention has already become most urgent, because of the constantly increasing losses due to floods.

2. The use of storage reservoirs as a means of controlling floods, although expensive, becomes more practicable where the value of property liable to damage is great and where the reservoirs can be used simultaneously for other beneficial purposes, such as power development and aiding navigation. The question of feasibility of storage reservoirs depends upon the relation between the cost of construction and the benefits to be derived in each particular case, and the benefits increase rapidly as the country develops. The time has already come, especially in the more thickly settled river valleys, when a stream must be considered with a view both to minimizing its harmful influences and to securing the maximum benefit from all its uses.

3. The lack of adequate information makes it impossible for the commission to specify on what streams the construction of reservoirs would result in benefits commensurate with the cost. In most cases little is known concerning stream flow and the physical conditions causing floods, or whether there exist reservoir sites suitable to afford the necessary relief. The extent of damages caused by floods on different streams has not, as a rule, been accurately determined, nor have investigations been made to ascertain the relation of the cost to the benefits that would be derived from the construction of reservoir systems. The commission is of the opinion that each case must be considered on its merits, after a thorough investigation of all the facts, and strongly urges the necessity of careful studies such as the one recently made by the Pittsburgh Flood Commission.

4. The Federal Government has no constitutional authority to engage in works intended primarily for flood prevention or power development. Its activities are limited to the control and promotion of navigation and works incident thereto. The commission is of the opinion that flood prevention is primarily a local problem, and the work of controlling floods should in the first instance be undertaken by the minor political subdivisions, but that the Federal Government may very properly participate with the localities in carrying out such works on navigable streams, where a substantial and necessary improvement to navigation will result. Unless some such policy as this is adopted and adhered to, there is grave danger that the Federal Government may go outside its proper jurisdiction and become involved in enormous expenditures which are for local benefit. It has sometimes been urged that the Federal Government should undertake works for flood prevention on nonnavigable streams which happen to cross a State boundary line. It is clear that in such a case, if navigation is not concerned, the Federal Government should have nothing to do with flood prevention. A method is provided in the Constitution by which the States may cooperate for this purpose.

5. The extent to which the Federal Government should participate in the expense of constructing a reservoir system at the headwaters of a navigable stream should be determined in each particular case by an investigation of Government experts possessing the necessary training and facilities for undertaking a study of this nature. If such investigation shows that the promotion of navigation will require the reenforcement of the flow of a stream during the dry season through

the aid of storage reservoirs and shows the number and cost of reservoirs necessary for this purpose, the Federal Government will have a satisfactory basis for sharing in the expense of constructing a larger system intended also for preventing floods. In this connection it should also be noted that the prevention of floods will indirectly benefit navigation, but this alone is not sufficient reason for the participation of the Federal Government in reservoir projects.

6. The commission believes, for reasons given on pages 25 and 26, that the Federal Government is justified in investigating the proposition to construct a system of reservoirs on the Allegheny, Monongahela, and their tributaries, such as that recommended by the Pittsburgh Flood Commission after its extended study of means for securing protection against further damage from floods, with a view to determining whether the Federal Government should cooperate with the localities in its construction. The commission accordingly recommends, following the plan suggested in the preceding paragraph, that a preliminary investigation be made to determine whether such reservoirs are needed to supply sufficient water during dry seasons to operate the present and proposed systems of locks and dams in the Allegheny, Monongahela, and Ohio Rivers, and to what extent the Federal Government, on the basis of their benefit to navigation, is justified in participating in the expense of their construction. In order to ascertain these facts the commission recommends that a joint board of engineers, one to be appointed from the Corps of Engineers, United States Army, and one from the Geological Survey, be created by Congress to investigate this question and to report to Congress not later than the beginning of the next session, and that the sum of $5,000 be appropriated to defray the expenses of this board.

V.

The Influence of Forestation upon Navigation and Flood Prevention.

The commission has given special consideration to the influence of forests upon the navigability of streams. The benefits attributed to forests are greater regularity of stream flow, the prevention or amelioration of floods, and the prevention of erosion, and the consequent silting up of navigable channels.

In recent years this subject has been widely discussed and many conflicting opinions expressed. Members of the Corps of Engineers, United States Army, and metereologists, as a rule, are inclined to minimize the influence of forests, while geologists, foresters, and others are inclined to emphasize it, and civilian engineers are about equally divided. There is a prevalent impression that deforestation is alike responsible for droughts on the one hand and floods on the other. The prevailing difference of opinion on certain phases of this question is due primarily to the lack of accurate information, which makes it extremely difficult to reach any final conclusions. Hence one purpose of this report is to clarify, if possible, the discussion, and to encourage further investigation. Certain conclusions and recommendations are also presented as to the most salutary policy to be pursued in the future. An exhaustive report on Forests and Water in the Light of Scientific Investigation has been prepared for the

commission by Mr. Raphael Zon, chief of silvics, Forest Service, which brings together the results of investigations in this country and abroad, and contributes a large amount of valuable information not hitherto available. This is attached as Appendix V.

Effect of forests upon stream flow.—Forests are said to cause a greater uniformity of stream flow by reducing the amount of water that reaches the streams in wet weather and increasing it during dry periods. It is generally admitted that forests exert an influence of this kind, but to ascertain its extent is a very difficult task. Attempts to arrive at some conclusion inductively by a comparison of river gauge records with the changes in the forested area of the river basin, making due allowance for the amount of precipitation, have not as yet produced any definite results. Two investigations of late which are worthy of mention have failed to discover any appreciable connection between stream flow and forestation. Prof. D. W. Mead, of the University of Wisconsin, has recently made a careful study of the rivers of that State and finds no changes in their flow which are not due to precipitation.[1] Deforestation in these river basins reached its maximum during the period 1882–1892, and since the latter date has declined considerably, but the river discharge records show no corresponding change. The second investigation was made by Lieut. Col. Edward Burr, of the Corps of Engineers, for the Merrimac River, in the States of Massachusetts and New Hampshire.[2] In this case conditions were particularly favorable for an investigation because of the existence of accurate daily gauge readings since 1849, and also records of precipitation since 1858. The Merrimac River basin was extensively deforested from the time of the early settlements until the period 1860–1880. Since this period approximately 750,000 acres of abandoned farm lands have reverted to timber, resulting in an increase of more than 25 per cent in the forested area. Col. Burr, after a careful study of the records, finds no variations in stream flow which correspond at all to the period of deforestation, and later of reforestation. It would manifestly be incorrect, however, to maintain that these two investigations settle the question, particularly since in both cases there are natural reservoirs at the headwaters of the streams studied, which exert a potent influence upon the uniformity of their flow.

Two other inductive studies of scientific value were made in 1907 by Mr. Leighton, of the Geological Survey, and Messrs. Hall and Maxwell, of the United States Forest Service, the purpose of which was to show that a number of the streams in the eastern part of the United States, such as the Ohio, Tennessee, and Connecticut, were becoming more irregular in their flow.[3] This increasing irregularity was attributed in both studies mainly to the deforestation of the river basins of these streams, but no data showing the amount of deforestation were presented in support of this conclusion, and it must therefore be accepted simply as the opinion of the writers. It is probable that a number of other influences which naturally accompany an increase of population, such as encroachments along the shores, the building of roads, and the increased cultivation of farm lands in these river basins, have also been important factors.

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[1] The flow of streams and the factors that modify it, with special reference to Wisconsin conditions. (Bulletin of the University of Wisconsin, No. 425.)

[2] House Document No. 9, 62d Cong., 1st sess.

[3] Report of National Conservation Commission, vol. 2, pp. 85-125.

In general, studies of an inductive nature are impossible because of the lack of accurate records of river discharge, precipitation, and the area of a watershed under forest cover at different periods. Furthermore, on a river basin of considerable size there are so many conflicting influences affecting stream flow that the influence of forests must be marked in order to be detected. Experiments are now being carried out on two streams in Switzerland, under the direction of the Hydrographic Institute of that country, and also by our Forest Service, in conjunction with the Weather Bureau, on two streams at Wagon Wheel Gap, Colo., to discover by a study of river records the effect of forests upon stream flow. In these cases streams of very small drainage area have been selected in order to avoid the difficulties which would be encountered on large river basins. The two streams under investigation in Switzerland have a watershed of 140 and 175 acres, respectively. They are similar in topography, geographical formation, soil, and latitude, but one is 90 per cent wooded and the other only 30 per cent. The plan of the experiments conducted by the Forest Service in Colorado is to collect precipitation and stream-flow records for a number of years for both streams as a basis of comparison, and then to deforest one of the tracts and note the results. This will require a considerable number of years before final results can be obtained.

Some experiments are also being conducted on the tributaries of the Pemigewasset in New Hampshire by the Geological Survey to discover what changes in the flow of these streams has resulted from deforestation and forest fires. In order to save time the plan is to compare the rate and volume of flow in the streams draining deforested and burned-over areas with those having forested watersheds. Eight different streams with basins presenting almost every conceivable condition from a virgin forest to complete denudation are being compared and the effect upon run-off and stream flow of each storm noted rather than the average effect over a long period of time. In this respect this investigation is a novel one, and its results will be awaited with much interest. Care has been exercised to obtain complete precipitation and snow records, and in the final results allowance is made for these, as well as for the difference in the slope and other factors that enter into the question.

A popular method of showing the influence of forests upon stream flow, which although inductive can not be considered scientific, is to compare the flow of two streams, one with a wooded and another with a deforested watershed, or to cite cases where springs have dried up after forests have been cut off, without any reference to the amount of precipitation in each case. A large number of examples of this kind were collected by the National Conservation Commission. Such illustrations, however, should not be regarded as conclusive evidence of the harmful effect of deforestation. They are of little scientific value unless records of precipitation are also given to make certain that the drying up was not due primarily to this cause. Such illustrations would also be more valuable if they were accompanied by definite information as to the extent and manner of deforestation, whether the land was entirely cleared or left covered with underbrush, or whether it had been burned over or broken up for agricultural purposes. There are examples of equal value where the flow of streams has improved as the result of deforestation and where

streams whose sources are in densely forested regions are much more violent than those which come from sparsely wooded or barren slopes.[1]

The proof of the influence of forestation upon stream flow has more often been sought by analyzing separately its influence upon each one of the different factors affecting stream flow. This so-called physical method lends itself more readily to experimentation and has thus far given more substantial results than any other, although many of the conclusions are open to criticism. For many years experiments of this sort have been carried on, especially in Europe, the results of which indicate that theoretically at least forests do exert considerable influence upon the different factors, particularly precipitation and run-off, which combine to affect stream flow. The main difficulty with this method, however, is that, while the effect of forests upon a single factor may be clearly established, when all the conflicting influences which enter into the situation are combined, as in nature, the resultant effect is never certain.

The results of these investigations, which are well presented by Mr. Zon in his report, will now be considered, and their value toward the final solution of this question discussed.[2]

Effect of forests on precipitation.—Forests are said to affect stream flow beneficially by increasing precipitation, and thus causing more water to be available for a stream. Numerous experiments have been made to determine whether more rain falls over a forested area than would fall over the same tract of land if deforested. As a rule these experiments show that rain gauges placed over forests catch more water than those placed on the edge of forests or in the open fields. Regular observations taken at Nancy, in France, for a period of 33 years showed that if the amount of rainfall at the center of the forest be designated as 100, the amount of rainfall at the edge of the forest would be represented by 93.9 and the rainfall outside the forest by 76.7. It also appears that the difference in rainfall over a forested as compared with a deforested area varies directly with the altitude, being negligible in the lowland and as great as 25 per cent in mountainous regions. Some experiments carried on in northern Germany showed that in the plains the difference was hardly perceptible, while at an elevation of 3,000 feet or more the difference amounted to several inches.

Several explanations have been given for the greater precipitation shown by rain gauges placed over forests. Prof. Cleveland Abbe, of the Weather Bureau, and some other authorities attribute the difference entirely to the imperfections of rain gauges, and explain that the greater catch of those placed over forests is due to the fact that the leaves and branches of the trees break the force of the wind so that less water is deflected from the gauge than is the case in the open. That the imperfections in the rain gauges are at least responsible for a considerable portion of the greater catch over forests is generally conceded, but is it not known conclusively as yet whether they account for the entire difference. Some experiments with improved rain gauges placed on scaffolds above the tree tops tend to indicate that they are not.

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[1] See especially H. M. Chittenden, Forest and Reservoirs in Their Relation to Stream Flow, pp. 933 and 934; also Report on Climatological Service, U. S. Weather Bureau, for September, 1911, pp. 5 and 6.
[2] See Appendix V, p. 207.

Another explanation frequently given for the apparent increase of precipitation over forests is that the chilling effect of the forest causes the moisture of rain clouds to condense more rapidly. It is undoubtedly true, as shown by numerous experiments, that the temperature in summer within a forest is considerably cooler than the temperature without. But whether this cooling effect extends far enough above the forest to cause condensation of passing rain clouds is not definitely known. In winter months no such effect could be exerted, because the temperature of the forest is then warmer than the temperature without. Furthermore, the real causes of precipitation are not as yet well understood. The heavier rainfall on mountain slopes is believed to be due to the raising of storm clouds in passing over them. If forests do cause greater precipitation by their cooling effect, it obviously will be most marked in high regions where storm clouds pass nearer to the tops of the trees.

Another explanation is that the tree tops of forests offer resistance to the moisture-charged winds and intercept a certain amount of rain or snow that otherwise would be blown along some distance before reaching the ground. This effect, as shown by experiments, is especially noticeable in the case of snowstorms, the amount precipitated over a forest being much greater than over open ground. If this is the correct explanation for the influence of forests upon precipitation, it would also be in harmony with the fact that rain gauges show a greater difference in catch in high regions than in the lowlands, because in such regions the winds have a greater velocity and if unimpeded would deflect more water from the rain gauges.

A third explanation is that forests attract storm clouds in their direction; but this has nothing in its support except the mere coincidence that in general rainfall is heaviest in mountain regions where the percentage of lands still under forest cover is greatest.

From information presented by Mr. Zon in his report it appears that forests transmit enormous quantities of moisture to passing winds, particularly when they are located in moist lowlands, and the moisture thus transmitted aids the precipitation somewhere else. For example, he states that the precipitation in the Central or Prairie States would be much smaller than it is now if it were not for the fact that the winds from the south and southeast absorbed moisture from the vast forest areas bordering the shores of the Gulf of Mexico and the Atlantic coast and also the Appalachian Mountains.[1] This influence of forests upon investigation is likely to prove much more important than any direct influence which they may have upon precipitation.

An impartial consideration of the results of investigations relating to the influence of forests upon precipitation does not warrant the assertion that such influence is marked, nor can it be said that forests exercise no influence whatever. The present status of this question was very fairly stated in 1902 by Prof. B. E. Fernow in Bulletin 7 of Forest Service, page 125:

> Altogether, the question of appreciable forest influence upon precipitation must be considered as still unsolved, with some indication, however, of its existence under certain climatic and topographical conditions in the Temperate Zone, especially toward the end of winter and the beginning of spring.

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[1] See Appendix V, p. 225.

Whatever influence forests may have upon precipitation, it certainly is not sufficient to appreciably affect stream flow and the navigability of streams and thus is not essential to this discussion.

Effect of forests upon run-off.—The influence of forests upon the run-off of rainfall, because of its equalizing effect upon stream flow, is considered much more important for navigation than the influence upon precipitation. The rainfall over a forest, as Mr. Zon explains, is carried off in five different ways:[1] (1) Part of it is intercepted by the leaves and branches of the trees, and evaporated into the air; (2) another part is evaporated from the soil within the forest; (3) a third part is absorbed and used by plants and trees for transpiration and tissue building; (4) a fourth part runs off from the surface of the slope; (5) the surplus or that which remains after these other purposes have been served filters through the ground and feeds springs and streams. The amount of water evaporated from tree tops and absorbed by forests in transpiration are losses directly due to forests and vary greatly under different conditions. The amount of rain evaporated from the tree tops depends, among other things, upon the character of the trees, their age and density, the amount of precipitation, velocity of wind, and temperature, and sometimes, as already indicated, assumes large proportions. Likewise, the amount of water absorbed by forests for their own use depends upon the character of trees, temperature, and numerous other factors. Forests conserve water to the extent that the lower temperature and more humid air within retards evaporation from the surface, and the forest humus absorbs the water which would otherwise run off on the surface. The water thus retained goes to reinforce the supply of ground water and eventually benefits the flow of springs and streams. On level ground, of course, there is practically no run-off, and the forests have comparatively little effect. In such cases, especially in the lowlands, it is quite probable that the loss of water due to forests exceeds the amount conserved.

The manner in which forests retard the run-off on slopes is as follows: The force of the rain is broken by the tree tops so that it reaches the ground gently, and the water caught by the leaves and branches continues to drip for a considerable time after the rain has ceased. The forest litter readily absorbs the water instead of allowing it to evaporate or to run off on the surface. The water thus absorbed percolates into the substrata, following the roots of trees, and finally by seepage reaches springs and streams.

It is generally admitted that forests exercise such reservoir characteristics and under favorable conditions to a sufficient extent to improve the regularity of stream flow. There is, however, a decided limit to the quantity of water which a forest cover can absorb. The capacity for absorption varies greatly under different conditions, depending upon the depth and character of the forest litter, as well as of the soil underneath, whether pervious or impervious, also upon the condition of the ground, whether frozen or not, upon the steepness of the slope, and numerous other factors. Where the forest litter is destroyed by forest fires, or is removed to prevent them, the absorptive capacity is thereby reduced.

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[1] See Appendix V, p. 228.

Various experiments have been made to ascertain the amount of water which different kinds of forest litter could absorb and hold. The results show that in general an amount equal to a precipitation of 0.16 of an inch can ordinarily be retained, while under favorable conditions the absorption of an amount equal to 0.24 of an inch or even more is possible. The soil beneath the humus may also be capable of some absorption. As soon as the saturation point is reached, additional rainfall must necessarily run off on the surface just as if the ground were deforested. This explains why forests are powerless to prevent floods, although, to the extent that they do absorb the precipitation, they may mitigate them.

Effect of forests upon floods.—Floods are caused primarily by a heavy and prolonged precipitation, amounting oftentimes to several inches within 24 hours. During the heavy rains which caused the disastrous floods in the Passaic Valley in October, 1903, 14 inches fell at Paterson, N. J., in less than 36 hours, and during the height of the storm more than an inch an hour fell, according to records taken at New York and Newark. The worst floods usually occur in the spring when these heavy rains fall upon a considerable accumulation of snow, which melts rapidly and augments the amount of water already precipitated. At this time the ground is more apt to be frozen or saturated and its capacity for absorption to that extent impaired.

Forests retard the melting of snow in the spring and by allowing the water from this source to be absorbed, exercise a beneficial influence upon stream flow, but should heavy spring rains fall upon the snow thus preserved and cause it to melt within a few hours the effect of the forest is in such a case to aggravate rather than ameliorate flood conditions. It thus appears that under one set of conditions forests may exercise a beneficial influence upon stream flow and floods, while under another their influence will be harmful.

Effect of forests on low-water flow.—Under normal conditions the rainfall which the forests have prevented from running off and aided in reaching the ground water will help to keep up the stream flow during dry seasons. But it may happen that in particular cases forests will tend to reduce still further the low-water flow of streams. In summer forests usually consume or give off to the atmosphere more water than they receive from precipitation. At such times they must draw upon the store of ground water for their needs. That they are capable of using up large quantities of water in this way is shown by the fact that in France and other European countries forests have been successfully utilized for the drying up of swamps. In dry seasons the absorptive capacity of the forest humus is greatly increased, so that it may absorb practically all the precipitation of local storms which might otherwise escape into the streams and aid their flow. On the other hand, if heavy fall rains should come after a period of prolonged drought, a forest cover would be in a most favorable condition to mitigate a possible freshet. Thus, as in the case of floods, the good effects or bad effects of forests depend upon the conditions existing at any given time.

The above consideration of the results obtained by use of the physical method indicates that it is useful in showing what influence forests have upon precipitation and run-off when taken alone, but, as already stated, it does not show whether in actual conditions this influence is beneficial or harmful. That depends in each case upon

the accompanying circumstances. Because of the limitations of this method, it can never be of great value in the final determination of the influence of forests under natural conditions.

Effect of forests upon erosion.—The most important benefit of forests is the prevention of erosion. For this purpose a forest cover is considered to be more serviceable than other covers, such as grass or underbrush, because of its ability to absorb more water and thereby to reduce surface run-off, and more economical because of the value of the lumber produced. In other respects it is doubtful if the forest cover has any material advantage over others. This being the case, it appears that the effectiveness of a forest cover to control run-off and prevent erosion depends upon the conditions affecting its absorptive capacity, the most important of which is the depth of the débris. Where the forest litter has been removed by man or destroyed by forest fires, erosion takes place more readily than if the soil were covered with grass or underbrush. Investigations made by the Geological Survey of a mountainous tract of land in Georgia showed that the hillsides which have been burned over, even though wooded, were badly washed. Aside from the character of the cover, the extent of erosion in any particular case depends upon such factors as climate, steepness of the slope, character of the soil, and the geological formation of the region. In the Southern Appalachian Mountains deforestation is almost always followed by some erosion, while in the White Mountains such result is rarely noted. The soil is firm and the new growth of underbrush comes in rapidly.

The erosion which forests would prevent affects the navigability of streams only to the extent that the eroded matter is washed down and deposited in the navigable channels. The damage resulting to the land eroded from the loss of top soil is the most serious consequence. There are numerous instances in Europe where the navigability of streams has been seriously affected by erosion. The best example, perhaps, is the Loire in France. Its channel, especially in the upper sections, has been gradually filled in with several feet of detritus, washed down from the eroded mountain sides. In France and some other European countries erosion has proceeded far enough to increase the frequency and damages due to floods. Where the channel is filled in with deposits of silt and the water flowing down carries with it large quantities of eroded matter, sometimes greater in volume than the water itself, every storm of any extent causes a freshet. In some cases large areas of agricultural land have been ruined by the deposits of waste matter left by streams which have overflowed their banks, while in other cases the overflowed lands have been fertilized.

The worst cases of erosion in this country occur in the southern Appalachian Mountains, but, while the damage done to property in some cases is considerable, the injurious effects upon navigation thus far have not been marked. It must be remembered, too, that neither here nor abroad is deforestation by itself the principal cause of erosion. Unquestionably the worst causes are forest fires and unscientific and careless methods of farming. Investigations in the southern Appalachian Mountains indicate that these are the principal causes of erosion in that region. Where a forest is cut off, there is usually a sufficient amount of underbrush and débris left to prevent serious erosion. In such places a new growth of briars and bushes soon springs up, which by the third year affords ample protection. It is

only on the steep mountain slopes, where the soil covering the rocks is thin, that deforestation by itself has serious results. The new growth comes in slowly, and before it can attain sufficient proportions to afford protection, the rocks may be completely denuded of all their soil cover. Ordinarily deforestation must be accompanied by clearing and breaking up of the soil for agricultural purposes before erosion becomes serious. The building of roads and trails on mountain sides is always a fruitful source of erosion.

The reports of Army engineers indicate that in some of our rivers dredging operations to remove silt have been necessary for the promotion of navigation, but what proportion of this silt is directly due to deforestation and not to other causes of erosion is impossible to determine. In tidal portions of streams the silting up is due primarily to the washing in of sand from the ocean. In the case of the Mississippi and Missouri Rivers, where the necessity of constant dredging has always been very great as well as expensive, the larger part of the silt forming these bars is not due to deforestation but to the erosion or caving of banks. Some are of the opinion that much of this silt comes from the barren bad lands of the upper Missouri. If such were the case the planting of forests here, as has been proposed, might perform a more useful service to navigation than anywhere else in the country.

Conclusions and recommendations.—Whatever influence forests may exert upon precipitation, run-off, and erosion, it is evidently greatest in the mountainous regions where the rainfall is heaviest, slopes steepest, and run-off most rapid. Here also the land is less useful for other purposes. The extent of the influence of forests upon these three factors varies greatly, according to circumstances involved in each case. Under one set of conditions, forests may benefit stream flow and mitigate floods, while under other conditions they may have the opposite effect. In no case can they be relied upon to prevent either floods or low-water conditions. There is substantial agreement on this point. Nor is their influence extensive enough to warrant their use as the only means of securing the uniformity of stream flow which is desirable for navigation or the development of water power. For this purpose storage reservoirs would be much more effective.

The prevention of erosion undoubtedly outweighs all other benefits of forestation and constitutes one of the most necessary phases of conservation. The commission favors the prevention of deforestation of mountain slopes wherever the land is unsuitable for agricultural purposes and urges the reforestation of those tracts which have already been denuded, not only when located at the headwaters of navigable streams, but wherever this would be the most valuable use of the land. The increasing pressure of population upon subsistence will make it necessary to use for agricultural purposes all land suitable for cultivation. The influence of forests upon stream flow and erosion is not sufficient to warrant their retention except where the land is unsuited for other purposes. Furthermore, it is possible, if correct methods of agriculture are employed, to retain for cultivation areas located on steep hillsides. This has been successfully accomplished in other countries by terracing and by other means.

It must be remembered, however, that reforestation alone can accomplish little toward preventing erosion. The prevention of forest

fires, the regulation of hillside farming, and the prohibition of complete denudation of mountain tracts, where the soil cover is thin and the land is unsuited for agricultural purposes, are also necessary. No policy of preventing erosion will be successful unless these three remedies are adopted. The Federal Government can render valuable service in cooperating with States and private individuals for the prevention of forest fires; but it has no power to regulate the methods of farming or the cutting of timber on private lands. For this reason State supervision is necessary if any important results are to be accomplished, because the States, through their police powers, can impose the necessary regulations. In European countries forests which must be preserved are designated by the Government as "Protective forests" and cutting in them prohibited except by the consent of some authority. Such regulations could undoubtedly be imposed by the States. By revising their tax laws on forest land, which now in effect in many States put a premium upon the rapid cutting of timber, the States could also encourage private capital to undertake scientific forestry as a profitable industry. The Federal Government, having no power to regulate the activities of private landowners within the States, can only prevent the wrongful use of lands by buying them, and even here its power is limited by the Constitution to the purchase of those lands at the headwaters of navigable streams which are necessary for the protection of their navigability. Such lands, in fact, constitute but a comparatively small proportion of all the lands that ought to be conserved. Furthermore, the cost of carrying out such a policy on any extended scale would be so great as to practically preclude the possibility of its success. The commission therefore believes that, with the exception of lands owned or acquired by the Government, the respective States are the proper agencies to undertake the preservation of forests and the reforestation of mountainous tracts within their borders, cooperating, if necessary, for the prevention of forest fires and the introduction of scientific methods, with the Forest Service of the Federal Government.

VI.

Development and Control of Water Power.

The commission has given special attention to questions relating to the development and control of water power. This question is of interest to the Federal Government, both in connection with its control of streams for purposes of navigation and in relation to its policies respecting the public domain. In order to secure the most reliable and comprehensive information possible on this subject, hearings were held in November, 1911, at which the Secretary of the Interior and other Government officials, as well as several of the most expert hydroelectric engineers, and leading promoters and financiers of water-power development, presented their views. The report of these hearings has been published as Senate Document No. 274, Sixty-second Congress, second session.

IMPORTANCE OF THE SUBJECT.

Present laws inadequate.—The adoption of a comprehensive policy of water-power control is most urgent for two reasons: (1) Because

we are entering upon a period of unprecedented water-power development, which in time will constitute one of the greatest industries of the continent; and (2) because existing laws relating to this subject are in a most crude and unsatisfactory condition, not being adequate either for proper Government control of these enterprises or adapted to encourage water-power development. Because of the lack of legislation properly safeguarding the public interest, the Federal Government has withdrawn from entry many valuable power sites in the public domain, and has been forced, when granting permits for constructions in the forest reserves or upon public lands, to impose conditions so severe that few large developments have been undertaken. Likewise in the case of navigable streams outside the public domain, the lack of a fixed policy has left uncertain the extent and nature of the control which the Government intends to exercise, with the result that few developments have taken place.

As a result of the existing chaotic condition of the laws, and the multiplicity of jurisdictions involved, water-power development has been subject to an exceedingly vexatious and unnecessary handicap. Under the present state of the laws, if a company should wish to make a development within any of the National forest reserves, it must first appropriate the water in accordance with the laws and regulations of the State in which the forest reserve is located. It must then submit its plans to the Department of Agriculture for approval. If the plans are approved, upon the payment of a certain fee, a permit will be granted. As power sites are very apt to be located in places remote from the point at which the power may be utilized, it is generally necessary to build transmission lines of considerable length. Should these transmission lines leave the forest reserve and traverse other portions of the public domain, another permit, imposing similar conditions, must be secured from the Interior Department. The situation is still further complicated in the event that the lines must cross an unperfected homesteader's entry. Under the present provisions of law, neither the Government nor the homesteader can legally grant permission to cross the claim. Furthermore, if the stream on which the development is to be made happens to affect navigation, plans must also be submitted to the War Department for approval, and, finally, the right to construct the dam must be secured by an act of Congress. The permits which the Secretary of Agriculture and the Secretary of the Interior are allowed by law to grant are revocable at will, unassignable, unmortgagable, and subject to interference by the location of mining claims and the transfer of lands from one jurisdiction to another. It hardly need be said that this condition is so intolerable as to practically prevent any extensive water-power development within the public domain.

Conditions respecting the location of power dams in navigable streams are not much better. While there can be no question as to the right of the Federal Government to control all navigable streams for purposes of navigation, yet there is still some dispute as to the relative jurisdiction of Federal and State governments. The nature of the condition which the Federal Government may constitutionally impose in its grant for the construction of a dam is still subject to some uncertainty. So far it has been the policy of the Federal Government to limit the duration of its grant to a period not exceeding 50 years. The acts, however, contain no provision for renewal or,

in case a renewal of the grant is denied, for compensation for the property. The general dam act and apparently all the special acts making grants for the construction of a dam in a navigable stream, so far made by the Government have also contained a clause providing that the act may be altered, amended, or repealed at the will of Congress. It is evident that under these conditions grants are not only insecure, but that no company operating under such circumstances could render the most efficient and economical public service.

Conservation of fuel supply.—Undoubtedly the most important problem in the conservation of natural resources is that of our fuel supply. Our deposits of both anthracite and bituminous coal, which can never be replaced, are being gradually exhausted. More than 300,000,000 tons are being consumed annually in the production of power by the agency of steam boilers, while the vast potential energy of falling water is running to waste. The only possible means of conserving our fuel supply are (1) a less wasteful system of mining; (2) a greater efficiency in its consumption; and (3) what will be most effective, a curtailment of its use by the substitution of some other source of power. On the other hand the only way to conserve our water power is by developing and using it. Its present use will not lessen in the least the supply available in years to come. The least efficient use of coal is that of producing steam for motive power. The substitution of water power would, therefore, by utilizing a source of motive power now going to waste, and stopping the most wasteful use of coal, serve a double purpose of conservation.

The present annual production of coal is over 500,000,000 tons.[1] It is estimated by engineers, for instance by H. St. Clair Putnam, in his address before the First Conference of Governors in 1908, that the supply of anthracite coal will be exhausted within the next 60 or 70 years. The present increase in the consumption of bituminous coal is approximately 10 per cent per annum. Assuming that there will be the same average increase for the next 150 years, when the maximum will be reached, it is estimated that the supply of bituminous coal will become exhausted in about 700 years. While this is a long period in itself, it is not a long period in the life of nations, and plainly suggests the immediate necessity of taking such steps as may be practicable for the conservation of our fuel supply.

The primary water power resource of the United States is placed by different experts at from 30,000,000 to 35,000,000 horsepowers.[2] The total power possible by the storing of flood water and control of stream flow is estimated by Mr. Leighton of the United States Geological Survey, to be 200,000,000 horsepowers.[3] Of this vast potential energy, only about 5,500,000 horsepowers have thus far been developed.[4] By other prime movers, chiefly steam, over 26,000,000 horsepowers are being created.[5] Under the most efficient conditions of

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[1] Special Report of Census Bureau to National Waterways Commission, 1912, the exact figures being 514,000,000.

[2] The Hearings on the Development and Control of Water Power before the National Waterways Commission, Senate Document No. 274, 62d Cong., 2d sess., p. 11 (Mr. Dunn); p. 14 (Mr. Dunn); p. 32 (Mr. Stillwell); p. 211 (Mr. Newcomb); p. 272 (Mr. Leighton). Proceedings of the Conference of Governors in 1908, p. 294 (H. St. Clair Putnam).

[3] The Hearings on the Development and Control of Water Power before the National Waterways Commission, Senate Document No. 274, p. 275 (Mr. Leighton).

[4] The Hearings on the Development and Control of Water Power before the National Waterways Commission, Senate Document No. 274, p. 11 (Mr. Dunn); p. 14 (Mr. Dunn); p. 211 (Mr. Newcomb); p. 273 (Mr. Leighton, who gives the exact figures for 1908 as 5,356,680).

[5] The Hearings on the Development and Control of Water Power before the National Waterways Commission, Senate Document No. 274, p. 11 (Mr. Dunn); p. 33 (Mr. Stillwell). Proceedings of the Conference of Governors in 1908, p. 297 (H. St. Clair Putnam).

steam electric generation yet devised, it requires about seven tons of coal to generate one horsepower year, while under average conditions from 12 to 15 tons are so consumed.[1] About 340,000,000 tons of coal are now annually consumed in the production of motive power,[2] and of the latent energy of the coal so consumed, only from 5 per cent to 12 per cent is actually transformed into dynamic energy.[3]

Railroads are the largest users of coal for motive power, and the steam locomotive is among the agencies of lowest efficiency in its consumption. It is estimated that the amount of power necessary to operate these railroads, if electrically applied, could be generated in a modern steam electric plant by the consumption of not more than half the amount of coal now used. It may be noted in this connection that about one-third of the total energy produced by all prime movers is now electrically applied, and the proportion is steadily and rapidly increasing.

If plants for the production of power by falling water could be constructed at the same cost per unit of power as steam plants, the saving effected by the use of water would be exactly the cost of the coal consumed. Figuring the average cost of coal at $3 per ton, which is a price sure to be reached in the comparatively near future, and the average consumption of coal as 15 tons per horsepower year, the saving would amount to $45 per horsepower, but as a matter of fact, the cost of water-power construction per unit of power is very much the greater, and the actual saving thus effected is considerable less than this amount. At the conference of governors held in Washington in 1908, Gov. Hughes stated that after exhaustive study of the subject the New York State Water Supply Commission estimated the saving to be not less than $12 per horsepower, while the Wisconsin commission, appointed to investigate the subject in that State, placed the saving at $20, while other estimates place it as high as $26.[4] If we assume the actual net saving in producing one horsepower year by the use of falling water to be $20 over what it would cost to produce the same unit of power by the use of coal, and capitalize this amount on a basis to earn 10 per cent per annum, it would appear that in developing a water power, an investment of $200 per horsepower in excess of the cost of a steam plant capable of producing the same output would be justified. Thus in developing the 30,000,000 primary horsepowers available in the United States, an expenditure of $6,000,000,000 in excess of the cost of producing the same amount of power by steam would be warranted—an amount about six times as great as the capital stock of the United States Steel Corporation.

Of course these new developments will not take place until there is a market for the output and until conditions in each locality make it possible to produce the power in competition with other forms of prime movers. Even at the present price of coal, however, the

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[1] The Hearings on the Development and Control of Water Power before the National Waterways Commission, Senate Document No. 274, p. 26 (Mr. Taylor); p. 32 (Mr. Stillwell). *Note.*—This estimate of Mr. Stillwell's is undoubtedly the most recent and most reliable yet obtained. He informed the commission that his estimate was the result of averaging several thousand answers to inquiries. Reduced to horsepower years, the poorest results would show a consumption of about 21 tons of coal per horsepower year, 10 hours a day, or 50 tons for 24-hour service. The best results correspondingly show a consumption of 6 tons and 14½ tons, respectively.

[2] The figure above given is an estimate furnished by an expert of the Census Bureau.

[3] Proceedings of the Conference of Governors in 1908, pp. 299 and 300 (H. St. Clair Putnam).

[4] Wisconsin Survey Bulletin XX, p. 2; Report of Hustings and Krumrey (Wis.) "Water Powers, Forestry, and Drainage," Jan. 24, 1910, pp. 12-14; Proceedings of the Conference of Governors, 1908, p. 324.

above figures show what an enormous expenditure will eventually be justified in developing water power and thereby conserving the supply of coal.

Water-power development.—The first power resources to be utilized in this country, as probably in all countries, were those of wind and falling water. Small developments of water power were numerous throughout the Eastern States, being most frequently utilized for turning the burs of a custom gristmill. Under the conditions then existing the power was available only in the immediate vicinity of the dam site. In a few instances power could be so readily developed or the location was for other reasons so favorable that manufacturing centers of considerable importance grew up around some of these power sites.

A more extended development of water power during the early period was checked by the invention of the steam engine. The advantage of compressed steam as an agency of motive power in those days of abundant, widely distributed, and cheap fuel was quickly recognized. The power so created was more reliable, could be better controlled, was available in almost every locality and under almost any sort of conditions. The ready transportation facilities furnished by the railroads, which now began to develop with great rapidity, rendered our deposits of coal available for power purposes over a much more extended area than had hitherto been possible.

One of the most serious obstacles in the way of extensive development of water powers has been the fact that power sites are so frequently located at points remote from profitable markets and places where the power could be profitably utilized. But in recent years the invention of devices making possible high-tension electrical transmission has very largely overcome this disadvantage. Places adapted to become industrial centers because of the existence of raw material, facilities for transportation, abundance of skilled labor, or any other natural advantages may now be supplied with electrical power generated anywhere within a radius of about 200 miles.

The difficulty of securing needed capital has been another obstacle to water-power development. Testimony given before the National Waterways Commission tended to show that water-power development on a large scale has been attended with considerable financial risk. Many of the enterprises have been conspicuous failures, due to the cost of construction being greatly in excess of estimates, to unreliable data and miscalculations of stream flow, to the unsalability of the product because of its unreliability, to troubles growing out of the conflict of jurisdiction between States or between the United States and one of the States or a foreign Government, as well as to the ordinary troubles of manipulation and mismanagement.

The chief menace to the success of water-power development, however, is its unreliability. Unless supplemented by other power, the actual value of the plant must be measured by its lowest capacity, which is determined by the minimum flow of the stream. There are but few streams in the United States possessing power sites which have a sufficiently uniform flow to be reliable. Variations between maximum and minimum stream flow are frequently very great, in some instances as high as 500 to 1, as in the case of the Potomac at Point of Rocks, Md. Not infrequently the ratio is as

high as 60 to 1, which is about the variation of the Mississippi River at St. Paul, Minn.[1]

To overcome the disadvantages arising from variation of stream flow it is always desirable and often necessary to combine into one system plants located in different watersheds, so that fullest advantage may be taken of precipitation over a large area, which is very seldom evenly distributed. While auxiliary steam plants may be utilized to overcome this difficulty, their use adds very materially to the total cost of production.

The economies of a large water-power system, combining or utilizing a number of plants, are, first, those which usually go with the elimination of multiple managements and centralization in a single management, and, secondly, economies peculiar to the business. The most important of the latter are the equalization of the electric flow and the consequent raising of the average efficiency of the system above that of the plants taken separately, the possibility of more continuous operation by combining plants which have chiefly a day load with those which have chiefly a night load, the increased facilities and reliability of transmission by having more than one route of transmission, a fewer number of "spares"—that is, duplications of machinery held in reserve to meet emergencies—and probably also engineering economies in the way of adjusting the load to suit the maximum efficiency of the machinery used.

The possibility of monopoly in the field of water-power enterprises and the actual tendency in that direction have been very generally recognized. Commissioner of Corporations Herbert Knox Smith, in a report on the "Concentration of Ownership of Water Powers," gives a long list of companies which he regards as affiliated with either the General Electric or the Westinghouse corporations, and also mentions several other very large operating companies, such as the Southern Power Co., as evidence of the tendency toward combination and monopoly. Mr. Smith concludes that of the over 5,000,000 developed horsepowers in use in the United States, 1,879,000 horsepowers are controlled by 13 selected companies. The Wisconsin Commission above referred to reported that they found no evidence of a water-power trust in that State, but warned the people that both because of the nature of the business and the ambitions of captains of industry there was imminent danger of such monopolization. The important fact to be gathered from the entire discussion of this

[1] The following table, furnished by Mr. Leighton, of the Geological Survey, will give the maxima and minima of typical rivers of the United States, at specific points:

Stream and locality.	Maxima.	Minima.	Drainage area.
	Second-feet.	*Second-feet.*	*Sq. miles.*
Kennebec, Waterville, Me	157,000	730	4,270
Potomac, Point of Rocks, Md	400,000	790	9,650
Alabama, Selma, Ala	146,000	3,300	15,400
Tennessee River, Chattanooga, Tenn	357,000	4,800	21,400
Mississippi, St. Paul, Minn	80,800	1,200	35,700
Brazos, Waco, Tex	132,000	3	30,800
Yellowstone, Glendive, Mo	107,000	3,750	66,100
Grand River, Palisades, Colo	43,000	944	8,550
Salt River, Phoenix, Ariz	300,000	0	....
Sacramento, Red Bluff, Cal	254,000	4,650	9,300
Willamette, Albany, Oreg	188,000	1,870	4,860
Clark Fork, Newport, Wash	155,000	5,700	24,000

phase of the subject would seem to be not so much that financiers and promoters might find it to their advantage to promote a monopoly as that economic considerations and the natural character of the business make monopoly almost inevitable, and perhaps desirable when subject to strict public regulation. A form of possible monopoly, however, that needs to be immediately guarded against is the acquiring and holding of dam sites for speculative purposes where no immediate development is contemplated.

As already stated, the feature of water-power enterprises which has made large-scale operations possible is the use of high-tension electrical transmission. It may also be added that this is the element which has tended to promote its monopolistic character. While the methods and instrumentalities for long-distance transmission have probably not yet been brought to their highest state of perfection, they have reached a stage where electrical power can be transmitted at least 200 miles with a comparatively small percentage of loss. In fact, it is entirely possible to construct a line on which there would be an almost inappreciable loss. In practice, however, the cost of a line of so nearly perfect efficiency makes its construction impracticable. It is, however, entirely practicable to construct lines from 100 to 200 miles in length which will deliver at the point of distribution from 80 to 90 per cent of the initial energy. This high standard of efficiency is nevertheless subject to certain modifications, due to atmospheric conditions, crossing of high elevations, accident to and deterioration of insulation, and other causes. It is sufficient for our purpose to state that it is now entirely feasible to construct a single power plant which will create and distribute electrical energy over an area of more than 125,000 square miles. Possibly of still more importance and significance is the fact that by means of these high-tension circuits power sites on different watersheds may easily be connected up and tied together in one vast system which may be practically operated as a single plant. The advantages of this practice are very evident—namely, the ability to more nearly utilize the maximum precipitation over a large area, the increased reliability of service, besides numerous operating economies. It should also be noted that it is the development of these transmission lines which has generally given the business the character of interstate commerce and may very well be expected to eventually lead to its complete control by Congress.

In view of the conditions already outlined and of the fact that water power development lies almost wholly in the future, there is perhaps no more important question before Congress than to shape a broad constructive policy which will amply safeguard the public interest and at the same time promote the development of our water power under plans consistent with the maximum beneficial use of the water.

THE CONSTITUTIONAL POWERS OF CONGRESS TO CONTROL WATER COURSES.

Ownership of water.—Perhaps there is no subject of legal interest concerning which there has been a more extended or more fruitless discussion than the ownership of water. Under the common law it is the property of no one, although the rules for its beneficial use are

carefully enunciated in a long line of decisions. Blackstone says in his Commentaries:

> But after all there are some few things which, notwithstanding the general introduction and continuance of property, must still unavoidably remain in common * * * such are the elements of light, air, and water.

In a majority of the States of the Union the common law of waters prevails. Some of the Western States have proclaimed either by provisions of their constitutions or by statute that the water of every natural stream or lake is the property of the public; others declare it to be the property of the State, which is undoubtedly to be interpreted as meaning the property of the State in trust for its beneficial use by the people.[1]

The bed of the stream.—There is also extreme diversity of opinion and wide variation of laws and rules in the different States respecting the ownership of the bed of the stream. In some States the fee runs to high-water mark, in others to low-water mark, and in still others to the thread of the stream. Under the first two conditions the ownership of the bed of the stream undoubtedly rests in the State. However, as long as the Federal Government has a right of easement over the bed of the stream for the purpose of navigation and all purposes related thereto, it is largely a matter of incidental interest in whom the title vests, and it is difficult to see how it materially affects the right of the Government to exercise control of the stream. Whatever rights the several States enjoy because of their ownership of the bed of the stream or the waters thereof, and whatever right to the beneficial use of the natural and continued flow of the stream may vest in riparian owners, must admittedly be exercised subject to the paramount right of the Federal Government to exercise its sovereign jurisdiction over the streams for the protection or promotion of navigation.

Federal authority paramount.—The nature and extent of the rights enjoyed by the States and riparian owners will evidently depend on the nature and extent of control exercised by the sovereign authority. The narrowest possible view would be for the Federal Government to limit its activity to matters that immediately and directly affect questions of navigation in those parts of a stream which are actually navigable. That the Government may, however, constitutionally extend its jurisdiction to questions more remotely connected with the rights of navigation, or even wholly unrelated, can hardly be denied.[2]

The commerce clause.—It may not be out of place to refer briefly to the constitutional authority on which the power of Congress over streams rests and to the decisions of the courts which in various particulars have established, defined, and amplified the scope of Federal jurisdiction. Fundamentally, of course, the authority of Congress is derived from the commerce clause of the Constitution, which delegates to Congress the power "to regulate commerce with foreign nations and among the several States and with the Indian tribes." (Article 1, sec. 8, clause 3.)

Powers delegated to Congress given a liberal interpretation.—Whether the powers enumerated in the Constitution as belonging to Congress were to be given the strict and narrowest possible interpretation, to be construed as excluding every function not specifically "nominated

[1] See Appendix VII.

[2] See pp. 48-49.

in the bond," as is the case with the ordinary "written instrument," or whether they were to be taken as broadly defining a field of activity in which the Federal Government was to be supreme, came up for determination almost immediately after the adoption of the Constitution. The decisions in these early cases, which have ever since been followed with unfailing fidelity, unquestionably clothed Congress with plenary powers to employ every means, not expressly prohibited by the Constitution, for carrying into effect the duties of government laid upon it. Mr. Justice Marshall, in approaching the tremendous responsibility of making these first determinations as to the powers of Congress, used these pregnant words: "It is a Constitution we are expounding."

In the case of McCulloch *v.* The State of Maryland (4 Wheat., 421), Mr. Marshall, in stating the opinion of the court, placed the powers of Congress on the broad foundation consistent with his conception of the meaning and purpose of the Constitution when he said:

> But we think the sound construction of the Constitution must allow to the National Legislature that discretion, with respect to the means by which the powers it conveys are to be carried into execution, which will enable that body to perform the high duty assigned to it in the manner most beneficial to the people. Let the end be legitimate, let it be within the scope of the Constitution, and all means which are appropriate, which are plainly adapted to that end, which are not prohibited, but consistent with the letter and spirit of the Constitution, are constitutional.

Congress supreme within its constitutional sphere.—Another question of equal importance, which called for early determination, was that of the supremacy of the Federal authority. The right of Congress to enact any legislation appropriate and convenient for the full exercise of its powers having been established, it was still to be settled whether its jurisdiction was exclusive of any other authority. It was contended that in certain particulars at least it could exercise only concurrent jurisdiction with the several States. While the doctrine of "concurrent jurisdiction" may not be repugnant to good government and may even be very convenient thereto—the only important question being which governmental agency acts first—yet when a conflict of authority arises only one agency of government can be supreme.

Just such a conflict arose in the case above cited. The legislature of the State of Maryland had passed a law laying a tax on a local branch of the recently established Federal bank. The purpose of this enactment was to nullify, so far as the State of Maryland was concerned, the act of Congress creating the bank. When the case came before the Supreme Court of the United States, the Maryland statute was declared unconstitutional. In giving the opinion of the court, Mr. Marshall laid down the fundamental principle that—

> The Government of the Union, though limited in its powers, is supreme within its sphere of action, * * * and laws when made in pursuance of the Constitution form the supreme law of the land, "anything in the Constitution or laws of any State, to the contrary notwithstanding" (pp. 405 and 406).

Since this decision there has been no effective challenge of the proposition that the Federal Government exercises all the powers delegated to it with the full attributes of sovereignty.

The commerce clause includes control of navigable streams.—The power of Congress over navigation, under the commerce clause of the Constitution, was recognized from the beginning. At the time the

Constitution was adopted it was perfectly evident that the most important agency of commerce then in existence was that of shipping, especially our merchant marine. It is quite probable this was the particular thing in the minds of the framers of the Constitution when they incorporated the commerce clause into that document. This question did, however, come up for court determination. It was one of the particular questions before the court in the case of Gibbons *v.* Ogden (9 Wheat., 1), and it was there held that the term "navigation" was just as effectually contained in the meaning of the phrase "to regulate commerce" as though the word were actually used. In fact the court suggested that it was more fully and more comprehensively included than would have been the case if the word had been specifically used. This interpretation is undoubtedly correct because the term "navigation" as an element of a larger conception is subject to no narrow limits of definition. Mr. Justice Marshall, in delivering the opinion of the court in the case above cited, remarked:

> The power of Congress, then, comprehends navigation, within the limits of every State in the Union, so far as that navigation may be, in any manner, connected with commerce with foreign nations, or among the several States, or with the Indian tribes (p. 197).

With respect to the scope of the power given to Congress in relation to the control of commerce, he says:

> This power, like all others invested in Congress, is complete in itself, may be exercised to its utmost extent, and acknowledges no limitation other than are prescribed in the Constitution (p. 196).

This decision unquestionably affirmed the exclusive and supreme control of Congress over navigation.

The English definition of "navigable waters" enlarged.—The further question still remained, namely, what waters within and contiguous to the United States were navigable, and hence subject to regulation by Congress. The English definition of "navigable waters" undoubtedly prevailed in this country at that time. Under the English definition only the lower reaches of a stream in which the tide ebbed and flowed were regarded as navigable. But physical conditions in this country were so wholly different from those which prevail in England that this rule was found to be inapplicable, and was fortunately set aside before the navigation of our inland waters became a matter of great public importance. In the place of the English definition the rule was established that a stream is navigable in law which is navigable in fact. This rule was perhaps first clearly stated in the case of the Genesee Chief et al. *v.* Fitzhugh et al. (12 How., 443). Mr. Justice Taney, in stating the opinion of the court, said:

> It is evident that a definition that would at this day (1851) limit public rivers in in this country to tide water rivers is utterly inadmissible. We have thousands of miles of public navigable water, including lakes and rivers, in which there is no tide.

This decision definitely established the supremacy of Congress over the reaches of every stream which is navigable in fact, whether subject to the ebb and flow of the tide or not.

The authority of Congress reaches to the sources of every stream.—The right of Congress to assert its authority over nonnavigable reaches of a stream or its nonnavigable tributaries was a question still subject to much difference of opinion. Recognizing the lack of a definite understanding as to its right to prevent every construction in either the navigable or nonnavigable reaches of streams, Congress passed an

act in September, 1890, containing the following provision (26 Stat., 454):

That the creation of any obstruction not affirmatively authorized by law to the navigable capacity of any waters, in respect to which the United States has jurisdiction, is hereby prohibited.

To enforce this prohibition, suitable penalties were provided. Subsequent to this enactment the Rio Grande Dam & Irrigation Co. constructed a dam in the Rio Grande at a point considerably above the limit of its navigability. It was intended to divert the waters impounded by the dam for purposes of irrigation. The United States, through its district attorney, began proceedings to enjoin the construction of the dam and diversion of the water. This case put squarely before the court the question of the nature and extent of the control which Congress may exert over nonnavigable streams. Mr. Justice Brewer, in delivering the opinion of the court, used the following language:

It is urged that the true construction of this act limits its applicability to obstructions in the navigable portion of a navigable stream, and that as it appears that although the Rio Grande may be navigable in the Territory of New Mexico, this statute has no applicability. The language is general, and must be given full scope. It is not a prohibition of any obstruction to the navigation, but any obstruction to the navigable capacity, and anything, wherever done or however done, within the limits of the jurisdiction of the United States which tends to destroy the navigable capacity of one of the navigable waters of the United States, is within the terms of the prohibition. Evidently Congress, perceiving that the time had come when the growing interests of commerce required that the navigable waters of the United States should be subjected to the direct control of the National Government, and that nothing should be done by any State tending to destroy that navigability without the explicit assent of the National Government, enacted the statute in question. And it would be to improperly ignore the scope of this language to limit it to the acts done within the very limits of navigation of a navigable stream.

There can be no doubt, since the rendering of this decision, that the authority of Congress reaches to the remotest sources in the mountains of every navigable stream. It could hardly be said that any stream, no matter how small, which contributed its waters to a navigable water course did not, at least to some extent, affect its navigable capacity. Make it as small as you will, and yet it will be difficult for the courts to say that Congress had no right to exercise its jurisdiction. Furthermore, if the power of Congress to regulate these streams is established, it must not be forgotten that its power is just as potent and that it is just as sovereign in its capacity as when exercising control over the navigable reaches of such water courses. Any obstruction which Congress could order removed from a navigable reach of a stream it could have equal authority to remove from a nonnavigable reach; and any construction in or over such stream which would be illegal in the one instance would be illegal in the other, provided Congress should declare that such construction interfered with the navigable capacity of the water course taken as a whole.

Constructions in or over streams, either navigable or nonnavigable, are within the control of Congress.—The control of water courses for purposes of navigation inevitably includes the right to permit or forbid construction in or over such waters. The court, in the case of the Newport & Cincinnati Bridge Co. *v.* United States, said:

The paramount power of regulating bridges that affect the navigation of navigable waters of the United States is in Congress. It comes from the power to regulate commerce with foreign nations and among States.

Nor is this power limited to constructions or actions directly affecting the navigation of a navigable stream. Congress may control constructions or actions on nonnavigable portions of a stream or on lands adjacent thereto. The question at issue in the case of United States *v.* the Rio Grande Dam & Irrigation Co., supra, as well as in that of the United States *v.* North Bloomfield Gravel Mining Co. (81 Fed., 243), can lead to no other conclusion. That in actual practice it is generally recognized and conceded that the permit from Congress is necessary to construct a dam even in a nonnavigable reach of a river is strongly evidenced in the following acts of Congress. The names themselves sufficiently indicate that the dams were built in nonnavigable localities.

Thus dams have been authorized at "Porter Shoals" (act Feb. 5, 1907, 34 Stat., 712); at "the Des Moines Rapids" (act Feb. 8, 1901, 31 Stat., 764; act Feb. 9, 1906, 33 Stat., 712); at "Coon Rapids" (act Apr. 12, 1900, 31 Stat., 75); at "Rock Island Rapids" (act Apr. 5, 1904, 33 Stat., 158); at "Sauk Rapids" (act Feb. 26, 1904, 33 Stat., 52); at "Methaline Falls" (act June 1, 1906, 34 Stat., 205); at "St. Croix Falls" (act Feb. 6, 1903, 32 Stat., 802); at "Gregg Shoals" (act Feb. 5, 1907, 34 Stat., 876); at "Hatton's Ford" (act Mar. 2, 1907, 34 Stat., 1240); at "McDaniel Shoals" (act Mar. 2, 1909, 34 Stat., 1238); and at "Muscle Shoals" (act Mar. 6, 1906, 34 Stat., 52).[1]

To be sure, any of the dams here mentioned might have been a possible aid to navigation by providing slack-water navigation above the dam, or Congress might have concluded that they would not be a hindrance to navigation, or at least that other benefits to accrue to the public because of their construction would outweigh such slight obstruction as they caused. In any case the exact reason or motive which may have led Congress to grant the permit is not a matter of great importance. If it once be admitted that Congress may grant or withhold its permit for constructions in nonnavigable reaches of a stream on considerations affecting the navigability of the stream as a whole, then Congress may exercise that power under any state of facts which it considers suitable and proper. While it is well understood that with respect to a certain class of permits Congress has and will exercise this right, yet its own acts and the decisions of the courts imply a power much more extensive than it has ever yet exercised.

At any rate, if Congress were to pass an act requiring its permit before a dam could be constructed in any part of a water course, either navigable or nonnavigable, on the theory that such action was necessary to the control of navigation it would be difficult to show that it had exceeded its authority.

Congress may withhold its permit or grant with conditions.—It is certainly safe to assume that the permit of Congress is very generally necessary. In every case where the construction of a dam or the diversion of water would be illegal or unwarranted without the consent of Congress, it would seem to be the legal as well as the logical consequence that if Congress may forbid such construction or diversion it may also impose as a condition of its grant any terms whatsoever not in themselves involving a violation of the Constitution. Neither does it seem essential that the conditions imposed shall relate to purposes of navigation. Congress has made it a condition of its permit to construct a bridge: (1) "That the grantee shall not charge more than a certain price for the carriage of munitions of war, United

[1] See "Control by Congress of water power developed in navigable waters of the United States," by Edward B. Burling.

States mails, or troops;" (2) "That it shall admit a joint occupancy by other railroads upon certain terms." [1]

These and similar conditions have been upheld by the court. (See Stockton *v.* Baltimore Co., 32 Fed., 9; The Clinton Bridge, 10 Wall., 454; Canada Southern Ry. Co. *v.* International Bridge Co., 8 Fed., 190; Gilman *v.* Philadelphia, 3 Wall., 725; County of Mobile *v.* Kimball, 102 U. S., 691.)

Many special acts as well as the general dam act of June 21, 1906, and the amended act of June 23, 1910, provide for the construction of fishways in accordance with the requirements of the Secretary of Commerce and Labor, as a condition of the grant to construct the dam. Certainly the preservation of fish is not a condition incident to control over navigation. Yet the validity of this stipulation has apparently never been challenged.[1]

The fact that the condition imposed may, as a matter of fact, be intended to give Congress control over a subject which it otherwise could not control, is not fatal to its validity. The famous act of Congress laying a tax of 10 per cent on the issue of State banks was notoriously intended for another purpose rather than that of raising revenue. Yet the courts held that it was a constitutional exercise of the right of Congress to lay and collect taxes. If Congress has not transgressed its powers it does not seem pertinent to inquire whether it was inspired to any particular act by an unconstitutional desire and intention. Exactly this suggestion was made by the Court in the case of Doyle *v.* Insurance Co. (94 U. S., 535).

The facts in this case were as follows: The State of Wisconsin had revoked the license of a certain insurance company because it had removed a case to the Federal courts, contrary to the terms on which it was licensed to do business in the State. The Supreme Court had upheld the right of the insurance company to so remove its case, notwithstanding this restriction in its license, on the ground that the State of Wisconsin had no constitutional right to annul the jurisdiction of the Federal courts. Nevertheless, in the case above cited, the same court held that—

> If the State has the power to cancel the license, it has the power to judge of the cases in which the cancellation shall be made. It has the power to determine for what causes and in what manner the revocation shall be made (p. 542).
>
> The argument that the revocation in question is made for an unconstitutional reason can not be sustained. The suggestion confounds an act with an emotion or a mental proceeding, which is not the subject of inquiry in determining the validity of a statute. An unconstitutional reason or intention is an impracticable suggestion, which can not be applied to the affairs of life. If the act done by the State is legal, is not in violation of the Constitution or laws of the United States, it is quite out of the power of any court to inquire what was the intention of those who enacted the law (p. 541).

It would seem, therefore, to be a settled principle of law that where the power to grant or withhold a permit exists, then substantially any conditions not in themselves unlawful may be imposed as a condition of the grant. If such be the case, when the permit of Congress is necessary for the construction of a dam for power purposes, there can be no doubt of its power to impose charges or the right to regulate the rates to be charged by the operating company, as a condition of such grant.

There would seem to be a possible limitation, however, on the effectiveness of the control of rates and quality of service by Congress,

[1] See "Control by Congress of water power developed in navigable waters of the United States," by Edward B. Burling.

as the result of such a stipulation in its grant. While there is no doubt that such a stipulation would be binding and effective, so far as the grantee is concerned, there is some question, due to the fact that the relation is merely a contractual one, whether it would be effective as against a third party with sovereign attributes, as a State or municipality; whether, in fact, the grantee would not be subject to complete regulation by State or municipal authorities, and whether he could not, as an extreme possibility, be driven out of business in a hostile community by the imposition of oppressive local regulations.

Congress in the exercise of any constitutional power may perform any function incidental thereto.—Congress may, nevertheless, possess full power to control the business of its grantee, so far as the public interest may require, entirely free from any interference by the State or municipality, upon quite a different consideration. In the exercise of any legitimate power it has been repeatedly held that Congress may exercise any necessarily incidental function. For example, it has been held in the case of California *v.* the Central Pacific Railroad Co. (127 U. S., 1), that—

Congress has authority in the exercise of its powers to regulate commerce among the several States, to construct, or authorize individuals or corporations to construct, railroads across the States and Territories of the United States.

In the case of United States *v.* Burley (172 Fed. Reporter, 615) the court held that the United States Government could enter into an incidental arrangement with private individuals while carrying on a project for irrigating and reclaiming a large tract of arid public domain. The application of this doctrine to the question of water power created incidentally to the construction of a dam for the improvement of navigation is admirably stated in the Kaukanna Water Power Co. *v.* The Green Bay & Mississippi Canal Co., in 142 United States, 254. The court says, page 273:

But if in the erection of a public dam for a recognized public purpose there is necessarily produced a surplus of water which may properly be used for manufacturing purposes there is no sound reason why the State may not retain to itself the power of controlling or disposing of such water as an incident of its right to make such improvement. Indeed, it might become very necessary to retain the disposition of it in its own hands in order to preserve at all times a sufficient supply for the purposes of navigation. If the riparian owners were allowed to tap the pond at different places and draw off the water for their own use, serious consequences might arise, not only in connection with the public domain for the purposes of navigation, but between the riparian owners themselves, as to the proper proportion each was entitled to draw—controversies which could only be avoided by the State reserving to itself the immediate supervision of the entire supply. As there is no need of the surplus running to waste, there was nothing objectionable in permitting the State to let out the use of it to private parties and thus reimburse itself for the expenses of the improvement.

The value of this water power created by the dam was much greater than that of the river in its unimproved state in the hands of the riparian proprietors who had not the means to make it available. These proprietors lost nothing that was useful to them except the technical right to have the water flow as it had been accustomed and the possibility of their being able some time to improve it. If the State could condemn this use of the water with the other property of the riparian owner, it might raise a revenue from it sufficient to compete the work which might otherwise fail. There was every reason why a water power thus created should belong to the public rather than to the riparian owners. Indeed, it seems to have been the practice, not only in New York, but in Ohio, in Wisconsin, and perhaps in other States, in authorizing the erection of dams for the purpose of navigation or other public improvement, to reserve the surplus of water thereby created to be leased to private parties under authority of the State; and where the surplus thus created was a mere incident to secure an adequate amount of water for the public improvement, such legislation, it is believed, has been uniformly sustained.

On page 281 the court further says:

The dam was built for a public purpose, and the act provided that if in its construction any water power was incidentally created it should belong to the State and might be sold or leased, in order that the proceeds of such sale or lease might assist in defraying the expenses of the improvement. A ruling which would allow a single riparian owner upon the pond created by this dam to take to himself one-half of the surplus water, without having contributed anything toward the creation of such surplus or the public improvement, would savor strongly of an appropriation of public property for private use. If any such power were incidentally created by the erection of a dam, it was obviously intended that it should belong to the public and be used for their benefit, and not for the emolument of a private riparian proprietor. The cutting of the embankment, under the circumstances of this case and the appropriation of the surplus water which the water-power company had had no hand in creating was a trespass which the court had a right to enjoin.

The question of the rights of the Green Bay & Mississippi Canal Co., arising out of the legislation set forth supra in Green Bay & Mississippi Canal Co. *v.* Kaukanna Water Power Co. (70 Wis., p. 635), was again presented to the Supreme Court of the United States in the case of Green Bay & Mississippi Canal Co. *v.* The Patton Paper Co., reported in 172 United States, page 58. The court says, at the bottom of page 68:

Whether the water power incidentally created by the erection and maintenance of the dam and canal for the purposes of navigation in Fox River is subject to control and appropriation by the United States only in operating those public works or by the State of Wisconsin, within whose limits the Fox River lies, is the decisive question of this case.

Upon the undisputed facts contained in the record we think it clear that the canal company is possessed of whatever rights to the use of this incidental water power that could be validly granted by the United States.

The court also quotes at some length from its decision in 142 United States, 254, and, in speaking of the rights of the Green Bay Co., says, page 80:

So far, therefore, as the water powers and appurtenant lots are regarded as property, it is plain that the title of the canal company thereto can not be controverted; and we think it is equally plain that the mode and extent of the use and enjoyment of such property by the canal company fall within the sole control of the United States. At what points in the dam and canal the water for power may be withdrawn, and the quantity which can be treated as surplus with due regard to navigation, must be determined by the authority which owns and controls that navigation. In such matters there can be no divided empire.

Finally, on page 82, the court says:

Our conclusion, then, is that as by the judgment of the supreme court of Wisconsin there was drawn into the question the validity of an authority exercised under the United States, to wit, the granting of said water powers, thereby depriving the plaintiff in error of property without due process of law, the judgment of that court must be, and is hereby, reversed.

A petition was filed later for a rehearing of this case, which was refused, the court saying, 173 United States, page 190:

While the courts of the State may legitimately take cognizance of controversies between the riparian owners concerning the use and apportionment of the waters flowing in the nonnavigable parts of the stream, they can not interfere, by mandatory injunction or otherwise, with the control of the surplus water power incidentally created by the dam and canal now owned and operated by the United States.

It would seem that practically every dam constructed for the benefit of navigation, by virtue of which surplus water power was created, would present substantially the same conditions as those adjudicated in the cases above cited. It has been strenuously urged what the Government could do itself directly it could do with equal legality

by a private agency, which would then become an agency of government, and thus be clothed with a certain degree of sovereignty.

Federal control desirable.—The above survey of the powers which Congress has over the waterways of the country and questions incidental thereto admittedly indicates the extreme limit to which Congress may go under present decisions of the courts. But it is not to be supposed that Congress would be tempted to invade a field of activity which it could only enter by indirect methods unless it were perfectly evident and generally agreed that it was in the public interest to do so. It is well, however, that there should be no misunderstanding as to the extent of the authority of Congress if it should become necessary or expedient to exercise its full powers. With the increasing unity of our national life and the growing necessity of securing for human needs the maximum beneficial use of the waters of every stream it will become increasingly necessary to treat every stream with all its tributaries as a unit. In the nature of the case so comprehensive a policy could be successfully administered only by the Federal Government, and consequently the eventual desirability of Federal control is easy to predict.

CONTROL OF THE HYDROELECTRIC BUSINESS.

A commodity of interstate commerce.—While the most direct and effective control of the hydroelectric business would undoubtedly be accomplished by making it an incident of the general Federal control of streams, yet in view of the important hydroelectric development likely to take place in the near future, Congress may be called upon to exercise its power of regulation in a manner quite apart from its control over streams. The utilization of hydroelectric power very generally requires its transmission across State boundaries. The lines built for this purpose would then become the agency of interstate commerce, and would undoubtedly be held to be subject to Federal regulation. The Supreme Court of the United States has several times held that companies engaged in the electrical transmission of messages whose lines extend from one State to another are engaged in interstate commerce. The electrical transmission of power under exactly similar circumstances it is not to be doubted would also be held to be a proper subject of Federal control.[1]

Control of water power on the public domain.—The commission has also given considerable attention to the question of the development and control of water power on the public domain. Practically all Federal lands now lie in the Western States. In nearly all these States the common law of riparian proprietorship has been superseded by constitutional or statutory provisions to the effect that the water of all natural water courses is the property of the State. Each of these jurisdictions provides a procedure by which water may be appropriated for beneficial use. As practically none of the streams within the public domain is navigable, and Congress up to this time has not to any considerable extent extended its authority to control the navigable capacity of streams into their nonnavigable tributaries, the jurisdiction of the States over the water has so far been admitted

[1] Western Union Tel. Co. v. Texas, 105 Tex., 460; Western Union Tel. Co. v. Pendleton, 122 U. S., 347; Western Union Tel. Co. v. James, 162 U. S., 650; Western Union Tel. Co. v. Commercial Milling Co., 218 U. S., 406, 416; Western Union Tel. Co. v. Crovo, 220 U. S., 364.

by the Federal Government. But in order to prevent these great natural water powers from being exploited for private gain, the Federal Government has undertaken to control the situation by means of its proprietorship of the public lands. It has endeavored to accomplish this in two ways: (1) By withdrawing from entry a large number of the most valuable sites with the intention of withholding them temporarily until some adequate means of control can be provided; and (2) by conferring on the Interior Department and the Forest Service of the Department of Agriculture power to make rules for the use of public lands, which must be accepted as a condition of the permit for such use.

The only form of permit which these departments were authorized by law to grant was one revocable at will, and no provision was made for uniformity of action between the departments having jurisdiction, nor was any attempt made to harmonize the homestead entry laws or the mining-claim laws with this new administrative policy. Great confusion and the practical suspension of the water-power development has naturally resulted from this indirect attempt to do by the agency of proprietorship what could have been done with the utmost potency by the right of sovereignty. While the commission feels that eventually a comprehensive policy, based on the sovereign right of the Government to exercise complete control over every stream and having uniform application in all of the States of the Union, will be the only satisfactory solution of this important question, it recognizes that such a policy must be wrought out gradually. The recommendations hereinafter made it believes are consistent with such a plan and at the same time meet the most immediate needs for constructive legislation.

SPECIAL RECOMMENDATIONS.

The commission has considered and would suggest certain amendments to existing laws which they believe will materially better present conditions, both in respect to the development and control of water power on navigable streams and within the public domain.

The general dam act.—Several of these recommendations relate to the general dam act of June 23, 1910. Section 4 reads as follows:

That all rights acquired under this act shall cease and be determined if the person, company, or corporation acquiring such rights shall at any time fail, after receiving reasonable notice thereof, to comply with any of the provisions and requirements of the act, or with any of the stipulations and conditions that may be prescribed as aforesaid by the Chief of Engineers and the Secretary of War, including the payment into the Treasury of the United States of the charges provided for by section one of this act: *Provided*, That Congress may revoke any rights conferred in pursuance of this act whenever it is necessary for public use, and in the event of any such revocation by Congress the United States shall pay the owners of any dam and appurtenant works built under authority of this act, as full compensation, the reasonable value thereof, exclusive of the value of the authority or franchise granted, such reasonable value to be determined by mutual agreement between the Secretary of War and the said owners, and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of such properties: *And provided also*, That the authority granted under or in pursuance of the provisions of this act shall terminate at the end of a period not to exceed fifty years from the date of the original approval of the project under this act, unless sooner revoked as herein provided or Congress shall otherwise direct: *Provided, however*, That this limitation shall not apply to any corporation or individual heretofore authorized by the United States or by any State to construct a dam in or across a navigable waterway, upon which dam expenditures of money have heretofore been made in reliance upon such grant or grants.

Form of grant defective.—It will be noted that this section provides for a limited term franchise or grant, the term being limited to 50 years, and makes no provision for the disposition of the property at the expiration of the grant. Experience shows that this provision is not well suited to encourage development of water power or to protect the public interest. Nothing is more discouraging to the investment of capital than uncertainty. A grantee of the Government under this condition of grant might hope, if he had endeavored to render the best service possible under the circumstances, that Congress at the end of the grant would be inclined to treat him fairly or even generously and that he would not be deprived of his property without compensation; but considering that it is a hope which involves the uncertainty of future policies, it is one not easy to capitalize. The only safe supposition is that the plant will be forfeited to the Government at the end of the period, and on this basis the enterprise must be financed. This means that provision must be made for amortizing the plant by the end of the 50 years. The business must earn during this time enough to pay all operating expenses, the annual interest on the investment, charges resulting from depreciation and obsolescence, and in addition enough to repay the entire cost of the original plant, together with all improvements and additions; otherwise the enterprise is foredoomed to financial disaster. No company would accept a grant on such terms unless they were allowed to make such charges for their service or output as would enable them to meet all these financial obligations. Where prevented by the regulations of some State commission or by competition with other forms of power from collecting such charges, no development will take place. Hence the necessity of amortizing the plant, in addition to all other costs of rendering the service, will inevitably result in an increased charge to the consumer, which amounts to a tax, of doubtful equity, on the local community for the benefit of the General Government. This unnecessary burden could be avoided if Congress would enact legislation providing for a more equitable form of franchise.

Types of franchises considered.—The commission has given much consideration to the kind or form of franchise best adapted to protect the public interest and at the same time encourage water power development. The public interest requires first of all that the water powers be developed, for in no other way can these great natural resources be conserved, but the public equally requires that the franchises granted for this purpose shall contain ample safeguards for an adequate public control.

In discussing this problem of a suitable form of franchise three things should be constantly kept in mind: (1) That water-power development in the modern sense means hydroelectric development, which can be successfully carried on only on a large scale; (2) that in the nature of the case hydroelectric companies are liable to become public service or quasi public service enterprises; and (3) that they possess an inherent tendency to become monopolistic. The conclusion to be drawn from this state of facts is that their development should be carefully controlled in the public interest, and that their operation, service, and charges must be regulated by an adequate public authority.

The merits of the three ordinary forms of franchise, namely, the grant in perpetuity, the indeterminate grant, and the limited term grant, have been considered. Of these the grant in perpetuity may

be dismissed as not consistent with the public interest. If this form of grant is without compensation or restriction of any sort, it represents a mere squandering of natural resources, while an attempt to fix its value in advance is exceedingly difficult. Generally such grants result in placing a mortgage and handicap on the prosperity of future generations. A company operating with such a franchise and not subject to adequate restrictions is constantly tempted to abuse its powers by such methods as overcapitalization, high rates, inadequate equipment, and poor service. Probably no one would seriously advocate this type of franchise now unless he expected to be the beneficiary of the grant, although occasionally a community, in its anxiety to secure some form of public service, is willing to make almost any concession. Of course some of the defects of a perpetual grant can be cured by restrictions incorporated in the franchise, but practical experience with this type of grant has been so generally unsatisfactory that it can not be recommended.

The indeterminate grant is a type of franchise which provides for tenure only so long as the company is rendering satisfactory service. The essential feature of this form of grant is that it may be terminated at any time at will, or under fixed procedure, by the proper authorities. The property may be taken over by the public or transferred to a third party on the payment of a fair valuation. This form of franchise contemplates that the operation of the utility will be constantly watched and supervised by some established public authority. The franchise may contain restrictions or requirements, such as the payment of compensation, the rendering of an auxiliary service, or the periodic adjustment of rates, while minor conflicts of interest between the public and the utility company may be in constant process of adjustment through the agency of a public service commission or similar body. This form of franchise is especially suited to municipal utilities, where considerable elasticity is needed, because of constantly changing requirements of service, and also because in a compact community the character and needs of a service may be generally understood and its supervision readily accomplished. It might not prove equally applicable to the control of water-power development by the Federal Government, because no suitable administrative body exists, and because water powers, being scattered throughout the United States, would naturally be developed under widely varying conditions, with which it would be very difficult for any central commission to adequately acquaint itself. It may also be remarked that most of the features which have made the indeterminate franchise successful can be incorporated and applied equally well under the form of "term grants."

The limited term grant is a type of franchise which, in its simplest form, provides for a limited period of tenure and the reversion of the property to the governing unit at the end of the grant. Like all forms of franchise, it may be modified by an infinite variety of terms and conditions. Perhaps the most common modification is a special provision requiring payment for the property or making other stipulations as to its disposal upon the expiration of the grant. The chief objections to this form of franchise are (1) that it is impossible to determine whether it would prove to be in the public interest to take over a utility or renew negotiations for an extension of the grant at any arbitrarily selected time, and (2) that when the enormous amount and varied character of equipment usually required in operations of

this sort, and also the numerous and varying contracts involved, are considered it is evident that to wind up the affairs of such an enterprise on an arbitrarily selected date is a task of extreme difficulty. The special advantage of this form of grant is that the time finally comes when the public automatically repossesses itself of its rights and finds itself occupying a position of advantage in conducting future negotiations as its interests at the time may require.

While the period of tenure is a feature of undoubted importance, it is not in the sine qua non of a perfect franchise which it is sometimes assumed to be, the nature of the tenure might be such as to make the time element merely incidental. For example, a grant in perpetuity which contained a provision that some public authority might take possession of the property and operate it in the public interest or lease it to a third party for that purpose, guaranteeing to the original grantees merely title to their property and a reasonable return on their investment, would be a perpetual grant of an empty name only. It might be impossible to annul the charter, except by extraordinary procedure, but the only powers it granted could be readily recovered. So an indeterminate grant, which did not provide for a direct and effective way of ousting an unsatisfactory grantee at will, might prove to be "indeterminate" only in the sense that it could not be terminated. The suitability of a franchise to protect the public interest in any given case must depend on the nature of its terms taken in their entirety.

The undue reliance which has been placed upon provisions merely limiting the period of tenure as a means of curbing and controlling public-service corporations is based on certain misconceptions of the problem. All such provisions proceed on the theory that the service may be discontinued or the plant for producing it destroyed or removed. Where no such procedure is in fact contemplated, the reservation of this authority as a threat to be used in compelling good behavior on the part of the grantee only results in enhancing the risk of the investment and consequently the cost of securing capital for the enterprise, all of which must be eventually charged up to the consumer in the cost of service.

Much more intelligent franchises will be framed when two fundamental assumptions are thoroughly understood and conceded by both the grantor and the grantee: (1) That the service to be provided is to continue indefinitely, and (2) that the plant for supplying the service will always exist. Even if the latter assumption should prove incorrect, it is immaterial, for if a certain form of public service should no longer be required, the public interest would thereby disappear. In making the second assumption, of course it is not presumed that the original plant will always remain, but that a plant, renewed, enlarged, improved, and kept at the highest state of efficiency that new inventions and facilities may make possible, will be a permanent fixture. The public interest is to secure the best possible service at the lowest cost, which predicates the existence of an efficient and economical plant. If these assumptions are correct, the terms of a franchise ought to encourage and not discourage the creation of such a plant. This will be best accomplished by provisions that will assure the actual investor of the permanency and security of his investment, and guarantee to the public that every dollar spent in constructing and improving the property shall be expended honestly and as efficiently as human judgment will permit. In short, the permanency of the service

and of the plant to supply it are considerations quite apart from the agency which is to administer it. Unquestionably the terms of a franchise should afford to the governing unit the utmost facility in removing or replacing the agency operating a public utility whenever the public interest requires.

With respect to the proportion of the expense of building and maintaining any public-service plant that should be borne by those enjoying the service during any particular period, Mr. Milo R. Maltbie, of the New York Public Service Commission, for the first district, has the following to say:

If it is urged that the property of a public-service corporation should revert to the city at some time free of cost, one must ask, upon what grounds? Why should the present generation be burdened to accumulate a fund from which it gets no benefit in order that some future generation, some future class of users, may have the use of property free of charge? Why is it not just that each generation should bear its own burdens and pay the full cost of the services it uses and of the benefits it enjoys? Should not this theory be applied in short periods so far as possible, so that year by year the user would pay the actual cost, as nearly as it may be apportioned, of the service rendered to him?

Of course in computing "actual cost" there should be sufficient allowance to cover depreciation due to wear, obsolescence and inadequacy, insurance, and every other charge that might arise. If future generations are not to enjoy benefits for which they do not pay, they ought not to be burdened with debts or charges from which they get no benefit. If one is to err in either direction, it should be toward overcharging rather than undercharging the present. The future will have burdens to bear which can not be foreseen.

Compensation for property at end of grant should be provided.—The form of franchise provided in the general dam act of June 23, 1910, is a sort of combination of an indeterminate and limited term grant. It presents the rather anomalous situation that if the Government should take over the property at the end of 45 or 49 years it would be required to pay its actual value plus a substantial bonus, but at the end of 50 years the property apparently reverts to the Government, free of any cost. Probably it was not contemplated by Congress that the Government would ever actually acquire the property by either of these provisions. The provisions for ousting a grantee at any time on payment for the property is apparently intended to protect the Government against an emergency which would require the removal of a dam or other works, because of an unforeseen exigency of navigation. Since it is not specifically provided that at the expiration of the grant there shall be no compensation if the property is taken over by the Government, it can be assumed that Congress intended to postpone the establishment of a definite policy in that regard.

The commission would recommend that this act be amended so as to provide for the valuation of and compensation for property in the manner hereinafter suggested.

Valuation.—The most important objection to the form of grant provided by the general dam act, namely, that it contains no provision for payment for the property in case a grant is not renewed, has already been pointed out. In fixing the value of property in case it should become necessary for the Government to take it over or require its transfer to a new grantee, two factors are involved: (1) What property shall be included in the appraisal, and (2) by what method shall the valuation be determined.

As to the first question, it seems clear to the commission, after considering fully the nature of the hydroelectric business and the char-

acter of equipment required, that the dam, power house, machinery, and all other works and equipment appurtenant thereto, useful and convenient for the generation of hydroelectric or hydromechanical power, together with transmission lines extending from the power plant to initial points of distribution, should be included in the property taken over, but such valuation should not include any part of any distributing system, any auxiliary plant (unless it be appurtenant to and a part of structures built for developing the water power), or any other property, physical or otherwise, not already designated.

To formulate an equitable rule for determining the value of public service or quasi-public service enterprises is, generally speaking, a very difficult and complex problem. Much depends upon circumstances. In the case of Smyth *v.* Ames, 169 U. S. 466, one of the questions before the court was the proper method of determining what are reasonable rates of service. Mr. Justice Harlan, in delivering the opinion of the court, said:

The basis of all calculations as to the reasonableness of rates to be charged must be the fair value of the property used. In order to ascertain that value the original cost of construction, the amount expended in permanent improvements, the amount and market value of bonds and stocks, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by a statute, and the sum required to meet operating expenses, are all matters to be considered.

The commission is of the opinion, in case of grants relating to development of water powers, that the concern of the Federal Government or its obligation to the grantee does not extend beyond the guarantee of a reasonable valuation and compensation for the physical property already described, such reasonable valuation to be determined by mutual agreement between the executive officers of the Government and the grantees, and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of such property. The rule for determining the physical value should be the cost of replacing the structures and equipment with other structures and equipment which would produce and transmit the same amount of marketable power with equal efficiency, and to the amount so determined there should be added a premium of 10 per cent. The addition of a premium above the actual replacement value is undoubtedly justified, because in the development of any industry, even when carried on with the utmost skill and efficiency, there is necessarily a certain amount of experimentation and loss in replacing inadequate equipment, which is a perfectly legitimate element of the cost and value of a plant, but which is not represented in a replacement valuation.

Negotiations for renewal.—It is the common history of all franchises involving any form of public service that as the term of the grant approaches its expiration it becomes difficult to secure capital for any needed improvements or additions. Retrenchments are practiced, the service deteriorates, and much inconvenience is occasioned to the public, and ill feeling engendered. Most of these evils could be remedied by providing that negotiations for renewal may begin at a reasonable period before the expiration of a grant. The commission would recommend that not more than 15 years prior to the expiration of any grant for water power development or permit for the use of public lands either the Government or the grantee may open negotiations for its renewal and that during the pendency of

such negotiations, or at any time prior to the expiration of a grant, the Government may require the grantee to make any improvements or enlargement of its plant which the public interest may demand; and that not more than 10 years prior to the expiration of any franchise the Government may issue its grant to a new grantee, to take effect on the expiration of the orginal franchise, and shall, at an appropriate time, arrange for the valuation, sale, and transfer of the property.

The public domain.—The commission would also recommend certain changes in laws relating to public lands which it is believed will encourage the development of water power within the public domain and at the same time fully safeguard the public interest.

A person or company which desires to make a water-power development within the public domain in any locality not withdrawn from entry must first appropriate the water in conformity with the laws of the State in which such power site is located. He or they must then apply to either the Secretary of Agriculture or the Secretary of the Interior, as the case may be, for permission to use such portion of the public domain as may be required for the construction of the dam and power plant, and the transmission lines necessary to convey the power to market. Under existing law the respective heads of these departments can only issue a permit revocable at will, and subject to such charges and conditions as they may see fit to impose. These lands are still subject to entry either under the homestead laws or the laws relating to mining claims, and where such entry has been perfected it automatically revokes the permit. The permit is also automatically revoked in the event that jurisdiction over public lands covered by the permit is transferred from one department to the other; as, for example, the establishment of a forest reserve in the public domain would transfer jurisdiction from the Department of the Interior to the Department of Agriculture. Further, there is no provision for the establishment of uniform rules for the use of the public domain by these departments. The uncertainty of the tenure and conditions of the grant necessarily involved in this situation has practically defeated any considerable water-power development within the public domain. The commission would earnestly recommend that some relief from this condition be provided. It would suggest, first, that the mining laws be so amended that mining entries can be made in localities suited to water-power development, only under conditions that will not interfere with the convenient and suitable use of such lands for water-power development, and that use for water-power purposes, when a permit has been granted, shall be paramount to any other use. It would also recommend that homestead and other forms of land entries should be subject to the right of the proper authorities to issue a permit for the construction of transmission lines, conduits, ditches, or other necessary works over such claim, provided a reasonable compensation be made to the entryman in case the entry is perfected; or that the permittees of the Federal Government for the construction of transmission lines be given the power of eminent domain, or that both these remedies be granted.

It would also recommend that authority be granted to the proper executive officers to issue permits for a period not to exceed 50 years, subject to such reasonable conditions and charges as the public interest may require, that uniform rules for the use of the public domain

be formulated and promulgated by the departments, and that a transfer of jurisdiction over any public lands from one department to another shall not revoke the permit.

An executive board.—The commission has also considered the desirability of creating some executive authority, perhaps preferably an ex-officio board to consist of the Secretary of War, Secretary of the Interior, and the Secretary of Agriculture, which shall be authorized, under such conditions as Congress may impose, to grant permits for the construction of dams and appurtenant structures for power and other purposes in navigable streams and upon the public domain. Such a plan would give to Congress full opportunity to determine the general policy of such grants and make such changes from time to time as conditions might suggest, but would relieve it from the necessity of passing a special act for each grant, which to all intents is an executive function. A board so constituted would have the utmost facility for securing the most reliable engineering and other expert information necessary for an intelligent determination of the facts. Such a board would also most readily coordinate the activities of the departments having to do with the public domain, and would facilitate the promulgation of uniform rules for the use of public land.

Besides granting permits for dams in navigable streams and establishing uniform rules for the use of the public domain, such a board could most readily perform certain other administrative functions which Congress could not very conveniently or properly undertake, but for which every franchise should provide. One such provision has already been suggested, that of valuing and taking over or transferring to a third party the property of a grantee on the expiration of a grant, in case such a course were found necessary in order to protect the public interest. Such a board should also, in the first instance, be authorized to institute an examination to determine, in each case, whether a proposed development would be consistent with the utilization of the entire power possibilities of the stream as well as with the maximum beneficial use of its waters for all other purposes.

Another important administrative necessity is that of approving or forbidding the assignment of franchises. The securing of franchises for water-power development for purely speculative purposes, where there is no bona fide intention of making the development on the part of the original grantee, is one of the most evident dangers to be guarded against. The combining of competitive plants by assignment of grants for the purpose of eliminating competition and raising rates of service is another possible abuse of the privilege granted. The evils which might result in either of the above-described cases can be prevented by making franchises transferable only with the approval and consent of some public authority. Under other circumstances the assignment of a franchise might be in the public interest and highly desirable. The commission would, therefore, recommend that it be made a condition of every grant that it is not assignable except with the consent of the proper Government authority.

It is in the very nature of water-power development that in many instances it will involve contracts for long periods of service. In many instances there would be no justification for the development unless there were assurance that the service would continue indefinitely. For example, when water can not be secured by gravitation

for purposes of irrigation, and water power is developed primarily for pumping water for that purpose, uncertain or short-term contracts would not be acceptable or feasible. During the early years of a 50-year grant satisfactory contracts could probably be made, but as the life of the grant became shorter, it would be increasingly difficult to negotiate acceptable contracts, as a contract for service extending beyond the limit of the grant would render the grantee liable to damage for nonfulfillment in case his franchise was not renewed.

The public interest would seem to require that in cases where long-term contracts are essential to the welfare of the community, they should be permitted under suitable control. The commission would recommend that water-power grants should provide that during the last 25 years of the term the grantee may contract for the sale of power or the rendering of service for a period extending beyond the term of his franchise, provided such contract has the approval and sanction of some public authority; and in case the original grant is not renewed no other grant should be made unless the grantee shall assume the performance of such contracts.

Public use should be preferred to private use.—The commission has also given consideration to the question as to what extent a public, especially municipal use, should be preferred to a private use in making grants for water power development. As the supply of coal becomes exhausted, a source of power for the operation of certain public utilities is sure to become a matter of enormous public importance, although it is recognized that, generally speaking, this is a problem of only remote concern. As already stated, conservative estimates indicate that our supply of anthracite coal may become exhausted within the present century, and that our supply of bituminous coal, with reasonable allowance for increased consumption, will last some 700 years. In special instances, however, the requirement of power for public service purposes, for which coal is not readily available, is a very immediate and tangible concern. The commission would recommend that where conditions of this sort arise, public officials charged with the responsibility of issuing grants should give due consideration to the preference to which these uses are entitled.

Charges and regulation.—That a grant for water power development constitutes a special privilege, for which the Government is entitled to proper compensation, is a principle which should be clearly established. The actual value of such privilege will, of course, vary greatly under different conditions. Every grant of the Government should, however, be dependent on the payment of such reasonable charges as may be determined by the circumstances and equities involved in each case. The commission does not suggest or advise that this right or power of Congress should be invoked as a means of raising revenue for general purposes, but only to reimburse the Government for the cost of surveys, inspection and similar expenses, and for the purpose of controlling the use of streams in the interest of the public.

As already stated, it is the opinion of the commission that the hydroelectric business, both because of its intimate relation to the use of streams for purposes of navigation and because it will inevitably, in many instances, become interstate in the scope of its operations, must eventually become a subject of complete Federal control.

While we believe that the business has not yet reached a stage of development such as to make that policy immediately desirable, it is rapidly approaching that stage. The commission would recommend that for the present all questions arising between the operating company and the consumers of its product or service be left to the control of the several States within which such companies may be doing business, except in cases where the authority and power of neither municipalities or the State are adequate to protect the public interest; but with the fullest understanding that within the comparatively near future this feature of its regulation must also inevitably pass to the Federal Government.

Respectfully submitted.

THEODORE E. BURTON, *Chairman.*
JACOB H. GALLINGER, *Vice Chairman.*
SAMUEL H. PILES.
WILLIAM ALDEN SMITH.
F. M. SIMMONS.
WM. LORIMER.
JAMES P. CLARKE.
D. S. ALEXANDER.
FREDERICK C. STEVENS.
IRVING P. WANGER.
S. M. SPARKMAN.
JOHN A. MOON.

APPENDICES.

Appendix I.

PRELIMINARY REPORT UNITED STATES NATIONAL WATERWAYS COMMISSION.

The National Waterways Commission, composed of 12 members bers of the Senate and House of Representatives, was created by act of Congress of March 3, 1909. The duty imposed upon it by statute was to investigate questions pertaining to water transportation and the improvement of waterways and to make recommendations to Congress.

The commission has had under consideration the topics assigned to it, and has held numerous meetings, both in the United States and Europe. Seven of the twelve members took a somewhat extended tour for the examination of European waterways in the months from August to October last. In addition, a majority of the members of the commission examined the Mississippi River from St. Paul to New Orleans in November, 1909, and some of them also, during the same month, inspected the Missouri River from Kansas City to its mouth, and the Illinois River from its lower portion up to the head of navigation. It may be added that the commission includes in its membership Senators or Representatives who at different times during the last 10 years have examined nearly all of the waterways of the United States. Consequently its members are enabled to bring to the consideration of the problem a very considerable familiarity with the waterways both of the United States and of Europe as well. The commission has been aided in the course of its investigations by officials detailed from the War and Navy Departments, and has obtained the assistance of other experts in waterway transportation. In the framing of this report especial aid has been rendered by Rear Admiral C. S. Sperry, of the Navy Department; Col. W. H. Bixby, and Maj. F. A. Mahan, retired, of the Corps of Engineers, United States Army; and also by Prof. Frank H. Dixon, of Darmouth College, and Mr. E. O. Merchant, of Columbia University. Numerous inquiries have been sent to commercial bodies and waterway improvement associations, most of which have met with a cordial response. The officials of European countries, in which waterway systems have been developed, and our consuls abroad, have rendered generous aid in the furnishing of material and in affording suggestions.

Under the statute creating the commission, it was provided that a preliminary report should be filed not later than January 1, 1910, containing conclusions reached by the commission upon the several subjects investigated. Unavoidable conditions have caused a few days' delay.

The commission now presents its preliminary report. In reaching conclusions upon the specific items set forth in the statute creating

the commission, it has been deemed necessary to report also upon related topics, such, for illustration, as water power and bank protection, which are assuming prominence in connection with the river and harbor legislation.

It has been impossible to give such elaborate and careful investigation as the members desire to all of the questions pertaining to waterway improvement. In a later report it is intended that further recommendations will be made, and such additional material as may be collected will be filed with Congress. The conclusions presented express the unanimous opinion of all the members of the commission, except in one instance, as set forth on page 11.

Several articles prepared by Messrs. Sperry, Bixby, and Merchant mentioned above as assistants to the commission, and by others are attached as appendices. Some of these are statistical merely. These appendices are regarded as of very substantial value, although the commission expresses neither approval nor disapproval of the views therein set forth.

In reaching its conclusions the commission has separately considered the following distinct topics:

First. The reasons for decline in inland waterway transportation, together with suggested remedies therefor, and the relation between waterway and railway transportation.

Second. Canals, including especially the advisability and practical value of canals for deep-draft vessels.

Third. The necessary steps to be taken before the adoption of projects for the improvement of rivers and harbors, and the method of making appropriations therefor.

Fourth. The proper division between appropriations by the Federal Government on the one hand and the States, minor political divisions, and individuals on the other.

Fifth. The relation of waterway improvements to bank protection, flood and drought prevention, irrigation, and drainage.

Sixth. The most desirable policy relating to harbors, including the ownership and control of wharves and docks.

Seventh. The relation of waterway improvements to water power.

Eighth. Methods for the improvement of rivers, including the construction of locks and dams.

Ninth. Comparison of European waterways with those of the United States, including an investigation of European and American transportation rates both by land and by water.

I.

THE REASONS FOR DECLINE IN INLAND WATERWAY TRANSPORTATION, TOGETHER WITH SUGGESTED REMEDIES THEREFOR, AND THE RELATION BETWEEN WATERWAY AND RAILWAY TRANSPORTATION.

The commission has had under consideration the manifest decrease in water-borne traffic on a majority of the rivers and inland waterways of the country.[1] On many there has been an absolute decrease,

[1] The most reliable statistics relating to water-borne traffic are to be found in the Census Report on Transportation by Water, 1906, published in 1908; Report of the Commissioner of Corporations on Transportation by Water in the United States, 1909; and the annual reports of the Chief of Engineers to and including 1909. The commission has also examined numerous reports of chambers of commerce and trade bodies. See also Preliminary Report, Inland Waterways Commission (1908), pp. 35 to 176.

while on others the falling off has been merely relative. In these latter cases, although the aggregate traffic by rail and water has been greatly multiplied, the proportional share carried by water has very noticeably diminished. Perhaps the most striking illustration of this is the traffic of the Erie Canal. In 1880 this canal carried between Buffalo and New York 4,608,651 tons, or 18 per cent of the total traffic, while in 1906 (the latest year for which statistics are available) the canal carried only 2,385,491 tons, or 3 per cent of the total traffic, as against 78,703,315 tons transported by the New York Central and Erie Railways. Not only has the actual traffic on the canal decreased nearly 50 per cent since 1880, but the relative amount carried by the canal, as compared with the two railroads, has fallen off from 18 per cent to 3 per cent. Likewise, on as important a river as the Hudson, the local commerce, exclusive of what comes through the Erie Canal, has shown some decline, while as shown by the reports of the Army engineers, the commerce for the section of river between Coxsackie and the State dam at Troy, including the Erie Canal traffic, has declined from 4,045,895 tons in 1898 to 2,945,921 tons in 1908. On a number of southern rivers also, such as the Altamaha, Tombigbee, and Pearl, there has been a marked decline in river traffic.

Quite as striking is the decrease in traffic on the Mississippi River and most of its tributaries. The following figures emphasize this fact:

Freight shipments, Mississippi River system, for 1889 and 1906.

[Compiled from Census Report, Transportation by Water, 1906, p. 181.]

	1906.					1889—total tons.	Change since 1889.	
	Self-propellers.		Barges and tows.		Total tons.		Gain.	Loss.
	Tons.	*Per cent.*	*Tons.*	*Per cent.*			*P. ct.*	*P. ct.*
Upper Mississippi	153,932	25.8	441,953	74.2	[1] 595,885	[1] 3,947,364	......	85
Illinois River	32,764	31.0	73,062	69.0	105,826	180,264	......	41
Missouri River	84,790	8.2	952,269	91.8	1,037,059	} 2,132,820	......	49
Other tributaries above St. Louis	1,876	9.7	17,455	90.3	19,331			
Total upper river system	273,362	15.5	1,484,739	84.5	1,758,101	6,260,448	......	72
Ohio River system	1,246,437	8.2	13,980,368	91.8	15,226,805	15,796,968	......	3
Lower Mississippi system	835,587	32.8	1,710,600	67.2	2,546,187	6,232,087	......	59
Total Mississippi system	2,355,386	12.1	17,175,707	87.9	19,531,093	28,289,503	......	31

[1] These figures do not include ferry traffic at St. Louis.

Other tables furnished by the Department of Commerce and Labor, classifying these shipments by commodities, show that the main items of decrease have been logs and lumber, ice, grain, coal, iron ore, and general merchandise on the upper Mississippi River system, and grain, lumber, cotton, and general merchandise on the lower Mississippi River system. The decline in the rafting of logs and lumber is responsible for a considerable share of the decrease shown.

On the other hand, the traffic on the Great Lakes has increased enormously. The total commerce passing through the Sault Ste. Marie Canals, where very accurate statistics are collected, amounted

to 3,256,628 tons for the season of 1885, 21,234,664 tons for 1898, while for 1908 it had increased to 41,390,557 tons, and for 1909 to 57,895,149 tons. Increased channel depth and lock facilities have been provided from time to time to meet the increasing traffic. It should be stated, however, that the Great Lakes are in a class by themselves. Likewise on some rivers, such as the Monongahela, the Kanawha, and a number of minor streams, the traffic has shown a considerable increase. On the Ohio River the aggregate tonnage has been well maintained; also on portions of the Tennessee it has shown some increase. A notable feature of the traffic upon some rivers has been the development of transportation for short distances, including ferry traffic.

The most frequent argument for river transportation has been that for coarser freights over long distances water transportation afforded very great advantages. There can be little question of the general accuracy of this statement. A boat or barge floating in the water is readily moved and at low speeds requires far less power than the movement of a railway car or other receptacle for freight used on land. The general statement has been made and widely accepted that with an equal expenditure of power about five times as much freight can be handled by water as by rail. The expense of equipping a transportation line, at least so far as the boats are concerned, is but trivial in comparison with that of constructing a railway. River transportation again has a decided advantage in that the waters are free, and anyone having the requisite capital and ability can engage in the business. This tends to create competition and to prevent monopoly. Indeed, it may be asserted, as a general proposition, that in any highly advanced country it is extremely desirable that an abundance of transportation facilities be furnished and that means be afforded for the carriage of freight not only by rail, but by water as well. It is a matter of common occurrence that in years of great crops or unusual prosperity the railways of the country have been unable to provide for the prompt and efficient performance of their duties as common carriers. The existence of this condition affords an independent argument for the development of transportation routes by water, even in localities where shippers mainly depend upon railways.

It has been the aim of the commission to find the explanation of the marked tendencies which have become manifest in the diminished use of most of the inland waterways of the country, and, if possible, to point out certain remedies.

It is the opinion of the commission that the most important factor in the decrease of water-borne traffic alongside of and contemporaneously with the great increase in railway traffic is due to the relations existing between these two great agencies for transportation.

The many advantages which a railway has in competition with a water route may be grouped into two general classes.

1. Those inherent or fundamental advantages which are based upon permanent conditions.

The first and most important of these is the wider area of distribution available to railways. A railroad line can be constructed in any direction to any part of the country except the portions which are admittedly inaccessible, while the line of a river is fixed by nature in a single direction. Railroads are more readily adaptable to the

newly arising and ever-shifting demands of producing areas and of markets. In providing for the receipt and delivery of freight at factories or warehouses, branch lines or switches can be constructed. Railroads can reach all cities and towns alike, whether located upon the water or not, while obviously boats or barges can not be used except for the receipt and delivery of freight or passengers from or to localities upon waterways. The rapid growth of inland cities not located upon waterways, many of which have attained very considerable size, emphasizes the possibility of development where the dependence for transportation facilities must be upon railroads alone. Notable illustrations of such prominent centers are Birmingham, Ala.; Atlanta, Ga.; Columbus, Ohio; Indianapolis, Ind.; Denver, Colo.; and a great number of cities and towns which are not provided with facilities for water-borne traffic.

A second advantage of the railways, which can be counted as belonging to this class, lies in the increasing importance of terminals and the necessity for facilities for the prompt and economical loading and unloading of freight. The cost of hauling freight, as compared with the handling or delivery at terminal points, has experienced a great change in the last 40 years. The cost of hauling has very materially decreased, while the cost of handling and the expenses connected with terminal facilities, though diminished in many ways, have not decreased accordingly.

A third advantage in this class is intimately associated with the preceding, and arises from the readier transfer of traffic from one railway to another, as compared with transfer from water to land or land to water. This includes not only physical transfer of traffic, but the through haul of cars without break of bulk and a thorough organization for through billing over various roads, with facilities for easy settlement of joint accounts of the cooperating railways. In this connection may be mentioned a physical disadvantage of rivers, due to the very considerable oscillation in their levels. This fact makes it more difficult to provide convenient and adequate loading machinery and renders the receipt and shipment of freight proportionately more expensive. The variation in the Ohio River at Cincinnati is over 60 feet; that of the Mississippi at Grafton, Ill., below the mouth of the Illinois River, is 29.6 feet; at St. Louis, 43.92 feet; below Cairo and the mouth of the Ohio River, 45.6 feet; between Memphis and Helena, Ark., 54.75 feet; at Vicksburg, Miss., 58.98 feet; and at New Orleans, La., 21.02 feet.

Another consideration is that railways, as a rule, make a higher speed per hour and the distance to be traversed between terminals is usually shorter by rail. Furthermore, the railway is more reliable in its schedules. It should, however, be stated that on certain water routes in this country, especially in seasons of traffic congestion, freight is quite as promptly delivered, and in many instances more promptly, than on railways.

2. Those advantages pertaining to railways which may be deemed artificial or temporary. These are due to conditions not necessarily permanent in their nature.

The first and most important of these is the right of the railway to charge lower rates between points where their line is in competition with water routes.

Section 4 of the act to regulate interstate commerce contains the following provision:

That it shall be unlawful for any common carrier subject to the provisions of this act to charge or receive any greater compensation in the aggregate for the transportation of passengers or of like kind of property, under substantially similar circumstances and conditions, for a shorter than for a longer distance over the same line, in the same direction, the shorter being included within the longer distance.

The words "under substantially similar circumstances and conditions" found in this section have been interpreted to mean that the existence of actual water competition constitutes a circumstance sufficiently dissimilar to relieve the carrier from the operation of the law. Under this interpretation the cutting of rates, where water competition exists, has been carried to an almost unlimited extent. It is now a question whether the right to lower competitive rates has not been exercised to an extent much in excess of what was intended when the act was passed, and, it may be added, to a degree quite inconsistent with the most salutary policy for the commercial and industrial interests of the country.

A second of these artificial or temporary advantages of the railroads comes from the power to acquire steamboat lines or enter into agreements with them for the purpose of stifling water-borne traffic, either by operating the steamboat lines or by discontinuing their use upon competitive routes. In both methods, namely, in the acquisition and operation of steamboat lines in such a manner as not to compete with railways, and in removing them entirely from the field of competition, the railway companies of the country have been very active.

A third advantage arises from the refusal to pro rate on through routes where naturally freight would be carried part of the way by rail and part by water. In many cases the route, which apparently is the natural one, would be by water for three-fourths or more of the distance, yet the charge for the remaining railway haul is so considerable as to render carriage for the longer haul by water unprofitable.

A fourth advantage of the railways, in this class, is the far greater attention given to provision for warehouses, terminals, and the equipment for handling freight. On many of the waterways very little if any progress has been made during the last 50 years in furnishing modern facilities for the storage or handling of traffic. In each of a considerable number of cities located upon rivers and canals in Germany the members of the commission during their recent inspection trip saw a larger investment for terminals and for the storage of freight and handling of boats than exists on the whole of the Mississippi River above New Orleans.

It is to be noted that in localities where water-borne traffic has increased, as on the Great Lakes, careful and elaborate provision has been made for the handling of freight in the most economical manner. It is not, in the opinion of the commission, difficult to explain the remarkable increase in this locality. Upon the Great Lakes there is a demand for the shipment of freight unsurpassed anywhere. The great iron-ore mines of the upper lakes and the very large quantities of grain awaiting shipment toward the more populous regions of the Atlantic seaboard and for export to Europe, as well as the quantities of lumber, which, though greatly diminished, are nevertheless considerable, afford cargoes for the downward trip, while the great demand for coal in the territory tributary to the upper lakes and the great

supplies near to Lake Erie afford a return cargo which, though relatively much less in volume, is still very large. The equipment for the loading and unloading of freight at terminal points is more advanced than anywhere else in the world. The boats are constructed with a view to utilizing space, so that a given tonnage will carry the greatest possible load, and those carrying the larger part of the traffic are specially constructed with a view to rapid loading and unloading of their cargoes. On the Great Lakes there are, moreover, channels of 20 feet on through routes, with an equal depth in the large harbors. Notwithstanding the immense traffic on these Lakes, it is, however, a noticeable fact that the quantity of general merchandise or package freight has not kept pace with the far more rapidly increasing traffic in the staple articles—iron ore, coal, grain, and lumber. It is estimated that not more than 5 per cent of the total traffic on the Lakes is made up of materials other than those mentioned. The traffic in these staples passing through the Sault Ste. Marie Canal in 1907 included 97½ per cent of the total.

On the Monongahela River, which, next to the Great Lakes, affords the most striking illustration of the growth of inland water-borne traffic, coal mines are located at or very near to the river, and these supply a part of the almost unlimited quantity demanded for fuel in the mills and furnaces in or near to Pittsburgh. This coal is readily loaded from the mines into boats or barges and from them directly discharged to the mills or furnaces where required. About one-third of the coal moves beyond Pittsburgh to points on the Ohio and Mississippi Rivers.

On a number of minor streams, such as the tributaries of the Delaware, traffic has been well maintained by established boat lines which have been in existence for a very long time. One great advantage possessed by these streams is the possibility of delivering freight to towns not provided with railway transportation. Also, in some instances, there is a very considerable saving in distance.

In still another class, traffic, though not so well maintained, continues to be large, as on the Penobscot and Kennebec Rivers, to points upon which freight and passengers are carried by boats running from Portland or Boston; also on the Connecticut River, where the city of Hartford has a daily line to New York City. Such water routes involve a combination of river and coastwise traffic and are frequently able to provide for the delivery of freight more promptly than by rail.

It has repeatedly been urged that rivers should be improved because of the tendency of such improvements to lower railroad rates. This tendency can not be denied. It is very manifest in every portion of the country where rivers have been improved; and so considerable has been the effect that it has frequently been argued that even if a river channel should not be used at all it would be profitable to expend money upon it solely for the effect upon rail rates. The commission, while fully recognizing this fact, can not indorse this as a desirable policy to adopt. It rests, in the first instance, upon the transparent fallacy that the railways constitute an intrenched and uncontrollable monopoly which can not be reached by legislation or other orderly and legal methods; that the only way in which to compel them to lower rates is by the expenditure of large sums of money in the improvement of channels, which are to remain wholly or par-

tially unused. National or State legislation is certainly sufficient, and should be resorted to for securing proper reductions in railroad freight rates. Again, the subject of transportation should be considered as a great economic problem. The cost of facilities for carrying freight, whether borne by the Federal Government or by private capital, is a burden upon the resources of the country. While the tendency of waterway improvements to lower freight rates is an important element to be considered, the fundamental criteron should be whether a railway or waterway, when constructed or improved, will be a profitable investment of capital.

As regards remedies to overcome the second general class of advantages of railways over waterways, those designated as artificial or temporary, the commission has considered a great variety of propositions. It has been brought to our attention that in a number of instances railways have temporarily reduced rates and continued them upon a lower basis until competing water lines have been driven out of business. The commission would recommend that in such cases, when a rate is once reduced by a railway, it should not be permitted to raise the same unless, after hearing by the Interstate Commerce Commission, or other competent body, it should be found that such proposed increase rests upon changed conditions other than the elimination or decrease of water competition.

The most essential requirement for the rehabilitation of water traffic is, in the opinion of the commission, the establishment of harmonious relations between railway and water lines. It is quite as important that there should be cooperation between them as that greater depth of channels should be secured. A study of the water routes which are found to be profitable in the United States discloses the fact that in practically every case the boats upon them are operated in connection and in harmony with railway lines, and, on the other hand, many railways utilize boat lines either actually owned by, or operated in harmony with, them to their very great benefit. It thus appears that to an extent this cooperation already exists, and the transportation facilities of the country will, as we believe, be still further promoted by compelling joint rates and prorating agreements; also by requiring through bills of lading and physical connection between rail and water agencies. It is a waste of capital to construct separate systems of warehouses and terminals for railroads and waterways when they can be used jointly by both methods of transportation. Legislation, in order to be effective, must require terminal and wharfage charges to be reasonable whether these facilities are owned by railways or waterways.

There are many advocates of legislation which would give the Interstate Commerce Commission the power to prescribe minimum rates for railroads. Such legislation would rest upon the theory that the lowering of rates as a general proposition oftentimes operates merely for the benefit of a favored few who are able to take advantage of them, and that, applied to railroads, the exercise of such a power would prevent that ruinous competition between rail and water routes which drives the boats off the rivers and canals of the country. In France there is a fixed rule that there shall be a difference in rates of 20 per cent in favor of the waterways, and in case railways in competition with waterways desire to fix lower charges for the carrying of freight, application must be made to a commission, which invariably

refuses permission if water transportation would in any way be prejudiced or placed at a disadvantage.

The commission can not see its way clear to recommend a general power to fix minimum rates. In the development of the country a lowering of the cost of transportation is an important factor in promoting industries and commerce. The general tendency has been toward lowering rates, and any regulation which would directly or indirectly interfere with this tendency would probably be injurious rather than otherwise. A majority of the commission, however, would recommend giving the power to the Interstate Commerce Commission to prescribe minimum railroad rates whenever, in its opinion, the object of a railroad in reducing rates is to destroy waterway competition.

In dwelling upon the disadvantages of waterways we do not omit to mention the handicap which has existed on numerous rivers because of the delay of the Government in prosecuting projected improvements. This delay operates as a disadvantage, because those who contemplate the building of boats and the establishment of steamboat or barge lines are unable to proceed with confidence. On the other hand it should be said that the danger of ruinous railway competition is a far more serious obstacle to the development of waterway traffic. Under this competition many channels which afford ample depth and the opportunity for the economical shipment of freight have remained largely in disuse. The criticisms upon the policy of Congress because the development of water routes has not been prosecuted with greater rapidity fail to take into account the substantial facts which have in the past discouraged the development of river transportation.

Mention must also be made of the fact that in numerous instances, although appropriations for the improvement of channels have been sufficiently large to create a high degree of efficiency for purposes of navigation, the use of the improved channels has not been at all commensurate with the expense incurred, one reason being a noticeable lack of progressiveness in providing suitable boats or other means of conveying freight, and another, the failure to provide terminals having modern equipment and facilities.

No improvement by the Federal Government will suffice without the cooperation of communities and business interests upon which reliance must be had for the proper utilization of improved waterways.

It is advised that by legislation, and in every way possible, cooperation be also secured between rail and water routes. Especially where such cooperation can be secured, or suitable railroad service does not exist, the commission would recommend the improvement of waterways, which, on expert examination, are found to be profitable investments of capital and will be of economic value as a means for transportation. Such improvement, it is believed, will greatly promote general commerce and the development of the industries of the country.

In the course of their investigations the members of the commission have observed the lack of comprehensive statistical information upon inland waterway traffic. In some localities, as at the locks at Sault Ste. Marie, detailed statements are carefully prepared under the direction of the Army Corps of Engineers, giving the quantity and quality of the freight and the number of passen-

gers carried through the locks. Other reports made by the Corps of Engineers afford valuable information, though, in some instances, incomplete.

Available statistics are furnished by several different bureaus of the Government, but are strikingly lacking in uniformity and in sufficient classification as well. The terms "general merchandise," "miscellaneous merchandise," "unclassified freight," "package and packet freight" are used in the same general sense, though quite ambiguously as to what categories of freight are included.

It is recommended as desirable that a uniform system be established applicable to all waterways, under which statistics may be collected showing the volume and different kinds of traffic carried on the rivers and inland channels of the country. This will not only be valuable in affording suggestions as to the extent to which waterway traffic is increasing or diminishing, and thus assist in determining the legislative policy to be pursued, but will also afford information of very considerable service to the commercial interests of the country. It is to be noted that we are far behind several countries of Europe in the accuracy of statistics relating to inland navigation. It is desirable that the statistics should show not merely the number of tons carried and the money value of the same, but the distances over which commodities are transported, so that not only the number of tons carried may be ascertained, but the ton mileage as well. In many respects statistics of the latter are more valuable than of the former. In some instances ferry traffic which is carried a half mile or less is placed upon the same footing with traffic carried a thousand miles or more.

It is a question of detail for Congress to consider what agency shall be intrusted with the collection of these statistics. It is thought that the necessary information can be obtained by the expenditure of a comparatively trivial sum of money, and the duty may be imposed upon existing bureaus and officials, such as the Army Engineer Corps, the collector of customs, where the navigable channels are near to customhouses, and those engaged in the Steamboat-Inspector Service. Rules requiring masters or owners of boats to report the quantity of freight and the distance it is carried should be enforced.

The commission would also call attention to the desirability of more extensive information regarding the high-water, low-water, and average-water discharge of the various rivers of the country. Information of this kind has been collected for some time on the Mississippi River from its source to its mouth. Fairly accurate statistics are already available for the high and low water depths of this and other streams, but in addition to this it is recommended that statistics be collected and made available for the high and low water discharge. This will require a more extended examination of cross sections and velocities at typical places. Accurate information upon these points is necessary in order to frame and execute properly devised plans for river improvement. The cooperation of commercial bodies in furnishing statistics should be encouraged.

II.

CANALS, INCLUDING THE ADVISABILITY AND PRACTICAL VALUE OF CANALS FOR DEEP-DRAFT VESSELS.

Many advocates of the building of canals manifestly fail to take into account the very great advantage of natural waterways over artificial channels for purposes of navigation. Natural waterways have banks which have been formed through an unlimited time and are adapted to the flow of water between them. Save in arable soils, the banks have a certain degree of stability and operate as a bulwark against the wash or swell created by the passage of boats. Natural waterways pass through valleys and usually close to large and populous communities which have been located and developed in former days largely because of river transportation facilities. They are available for the passage of boats, and possess extra width at many places, by reason of which the development of docks and basins is much facilitated without extra cost for right of way. For a large portion of each year, during the high-water season, they allow the passage of boats of unusual draft.

Artificial channels may be constructed along a straighter line, but usually with great difficulties in the acquisition of property for their construction, as well as in the overcoming of differences in elevation; and topographical conditions may cause the route not only to pass at a distance from the existing large and populous communities but also to traverse regions where development may naturally be slow. Again, canals must be provided with protected banks to resist the great force of water which is put in motion by the passage of boats or barges through their channels. They are naturally limited in width because of the expense; the cost of a width sufficient for the handling of ocean boats is practically prohibitive, except for comparatively short distances. They may have an advantage in their greater freedom from silt or other obstructions to navigation, but this is ordinarily more than counterbalanced by the difficulty of obtaining an adequate water supply for the main channel or for the locks used in connection with it.

The commission has had under consideration the question of the construction of artificial canals adapted to the passage of seagoing ships. An examination of this subject has led to the conclusion that this class of waterways is only profitable under certain well-defined conditions, of which the following are the best illustrations:

First. Canals connecting navigable waters located near to each other, between which large traffic would naturally exist, except for rapids, a barrier readily overcome, or the existence of a comparatively narrow strip of land. The Sault Ste. Marie Canal, connecting Lakes Superior and Huron, is perhaps the best example. This canal, 1.6 miles in length and constructed at a cost of about $9,300,000, renders the almost unlimited resources tributary to Lake Superior available to the other lakes and provides for a return commerce considerably less in volume. Other illustrations are the Welland Canal, 26¾ miles in length, with 26 locks, connecting Lakes Erie and Ontario, and the Lachine Canal, constructed for the purpose of obviating rapids in the St. Lawrence River.

Second. Comparatively short canals, which save a very great sailing distance, such as the Suez Canal, 87 miles in length, which furnishes a substitute for the voyage around Cape of Good Hope and saves in the sailing distance from Northern and Western Europe to Calcutta 3,700 miles, and to Hongkong, by the Straits of Sunda, 3,300 miles. Also the proposed Panama Canal, 49 miles in length, which obviates a voyage around Cape Horn and saves in the sailing distance from New York to San Francisco more than 8,000 miles. Another illustration is the Kaiser-Wilhelm Canal, 53 miles in length, which, though constructed primarily for military purposes, is largely used for commerce and saves in distance for vessels bound from the English Channel to the Baltic about 200 miles.

Third. Canals from the sea to large cities situated not far from the coast, where communities have grown to large size and become great producers or consumers of freight without connection with the ocean. In these cases, with increased commercial and manufacturing importance, it has become a practical necessity to establish communication with the sea. The best illustration of this class is the Manchester Canal, 35½ miles in length, with a least depth of 28 feet. The canals in Belgium, from the North Sea to Bruges, to Ghent, and to Brussels, are also good examples of this class.

The reasons for the disadvantages of canals as compared with natural waterways are obvious. In a narrow channel a boat moves with much less speed and with far greater difficulty and danger than in a natural waterway where there is sufficient sea room. Since the speed of the slowest boat determines the speed of all, it is not probable that any time could be gained by using a canal unless the distance saved were very considerable. Also, there is the constant danger that in the handling of a large vessel, which is not adapted for navigation in a narrow channel, it will strike against the bank or works of construction and not only incur delay but also serious damage. This possibility increases the cost of insurance. It is conceivable, however, that with improved methods of handling vessels this disadvantage might be somewhat lessened. It should be added in this connection that persons familiar with navigation have stated, in answer to inquiries on this subject, that even if canals of deep draft should be constructed on certain proposed routes in this country and were entirely free from tolls or similar charges, large vessels would make no use of them, preferring to go where there is greater sea room. Ocean-going boats are so expensive in first cost and daily operation that the profits of a whole trip may be consumed by a few days' extra delay. Moreover, the expense per ton of carrying capacity is much greater for an ocean-going boat than for one used in interior waters. The model, also, and the method of handling is different. This difference in cost tends to neutralize any advantage gained in the use of artificial channels by ocean-going boats.

The higher average value per ton of carrying capacity for seagoing vessels over those of inland waters is shown by the following table, compiled from the United States Census Report on Transportation, page 21, which gives the figures for 1906:

	Average value of vessel per ton of carrying capacity.			
	Steam.	Sail.	Unrigged.	All vessels.
Atlantic coast and Gulf of Mexico	$133	$33	$18	$56
Pacific coast (including Alaska)	117	38	30	78
Great Lakes and St. Lawrence River	61	27	32	55
Mississippi River and tributaries	90	....	2	5
All other inland waters	103	32	10	18
Entire United States	95	33	9	39

It thus appears that the average value of vessels per ton of cargo-carrying capacity on the Atlantic coast and Gulf of Mexico is $56, on the Pacific coast $78, while on the Mississippi River and its tributaries it is only $5.

III.

THE NECESSARY STEPS TO BE TAKEN BEFORE THE ADOPTION OF PROJECTS FOR THE IMPROVEMENT OF RIVERS AND HARBORS AND THE METHOD OF MAKING APPROPRIATIONS THEREFOR.

The commission regards the present law, providing for preliminary steps before the adoption of projects for improvement, as well adapted to secure the best results. Under existing statutes it is required that when the improvement of a river or harbor is advocated, before any plan is adopted there should be legislation by Congress in the form of a concurrent resolution or other measure which shall direct that an investigation of the improvement be made. This investigation contemplates two successive steps—first, a preliminary examination; second, a detailed survey—both of which are made by the Engineer Corps of the United States Army, and are reviewed by an organization known as a "Board of Review," created by the river and harbor act of 1902, with the object of securing uniformity in recommendations before projects are adopted, and with the thought of bringing to bear upon the proposed improvements under investigation a more elaborate and careful consideration. If on the first or preliminary examination the report is unfavorable, no further action is taken without the further order of Congress. The law on this subject is contained in the river and harbor act of March 3, 1909. It is as follows:

In all cases a preliminary examination of the river, harbor, or other proposed improvement mentioned shall first be made, and a report as to the advisability of its improvement shall be submitted, unless a survey or estimate is herein expressly directed. If upon such preliminary examination the proposed improvement is not deemed advisable, no further action shall be taken thereon without the further direction of Congress; but in case the report shall be favorable to such proposed improvement, or that a survey and estimate should be made to determine the advisability of improvement, the Secretary of War is hereby authorized, in his discretion, to cause surveys to be made, and the cost and advisability to be reported to Congress. Such examinations and surveys shall be reviewed by the Board of Engineers for Rivers and Harbors, as provided in section three of the river and harbor act of March second, nineteen hundred and seven: *Provided*, That every report submitted to Congress in pursuance of this section, in addition to full information regarding the present and prospective commercial importance of the project covered by the report and the benefit to commerce likely to result from any proposed plan of improvement, shall contain also such data as it may be practicable to secure regarding (first) the establishment of terminal and transfer facilities, (second) the development and utilization of water power for in-

dustrial and commercial purposes, and (third) such other subjects as may be properly connected with such project: *Provided further*, That in the investigation and study of these questions consideration shall be given only to their bearing upon the improvement of navigation and to the possibility and desirability of their being coordinated in a logical and proper manner with improvements for navigation to lessen the cost of such improvements and to compensate the Government for expenditures made in the interest of navigation: *And provided further*, That the investigation and study of these questions as provided herein may, upon review by the Board of Engineers for Rivers and Harbors when called for as now provided by law, be extended to any work of improvement now under way and to any locality the examination and survey of which has heretofore been, or may hereafter be, authorized by Congress.

Under the foregoing plan if the final report is favorable, it is considered that a basis exists for the making of an appropriation for the proposed improvements. The recommendations of the engineer officers are not necessarily final, though since the passage of the law the rule has been adhered to as a fixed policy that no project should be undertaken by the Government or appropriated for which does not have the recommendations of the board of review and the Chief of Engineers. At the time of the creation of the board, in 1902, projects of an aggregate cost of $400,000,000 or more, recommended as worthy of improvement, either had not been commenced or were in a partly finished condition, and necessarily the work of Congress was one of selection, under which the most pressing projects alone were sure of attention.

The commission would advise that without a careful and unbiased examination of proposed improvements of the nature now required by statute no project should be adopted by Congress. Numerous propositions have been made for the creation of a board of public works, or other body, which shall decide upon the feasibility and desirability of propositions for expenditures on rivers and harbors. The commission is unwilling to recommend a change of this kind, and points to the fact that the past recommendations of the Engineer Corps have been carefully prepared and with a degree of expert knowledge and comprehension of the commercial needs of the country which could not well be supplied by any other body or organization. The advantages which attach to the Engineer Corps are obvious. The members are in the permanent service of the Government, and are free from those influences which would inevitably be brought to bear upon men in civil life. Those engineers now engaged in the work are carefully trained in the planning and execution of these improvements, and have special qualifications for judging the feasibility and the cost of proposed river and harbor projects. They also have a good general knowledge of the probable commercial results which would accrue, though on this point their opinions have not been regarded as conclusive. In this connection the commission would call attention to the necessity for an increase in the membership of the Engineer Corps.

The commission would recommend that hereafter the general policy be adopted of providing for the early completion of any and all projects which are undertaken, and that only such number of projects should be commenced as will be appropriated for and completed within a reasonable time. In this way definite results can be relied upon, plans can be made for the utilization of the streams improved, and, in addition, a very large saving in expense may be secured. If this is done, projects will be more carefully considered before they are adopted. Careful provision should also be made for the maintenance

of existing works, otherwise the improvements already made will deteriorate. In the general policy of improving streams in waterway systems, it is advised that the main stream be improved first and raised to an adequate stage of efficiency at an earlier date than the tributary streams; that in the improvement of any particular river, preference should be given to the lower portion, and that the improvement should proceed from the mouth up, unless the regimen of the river makes a different rule desirable, or an independent stretch of the river exists remote from the mouth upon which salutary results can be more readily obtained.

There are manifest benefits in securing standardization or equal depths in all channels, so that boats of the same size may be utilized everywhere. This would prevent the very considerable expense of loading and unloading whenever there is a transfer between channels of different draft or capacity. If a uniform depth can be secured, especially in locks and improvements of artificial construction, it should be accomplished. The fact, however, must not be overlooked that the very great difference in the size of the streams which make up any river system renders complete standardization difficult and exceedingly expensive, if not impossible.

The continuing-contract system was first tried in the year 1890. Under this plan the whole or any part of an estimated expenditure is, whenever desirable, authorized at one time, and the amounts needed as the work progresses are provided from year to year by appropriations carried in the sundry civil act. This system, to some extent and with beneficial results, has been used in each subsequent river and harbor act except in 1894, and its continued use is recommended. In the case of small streams or harbors, however, it is not essential. Nor is the authorization of a contract for completion desirable, as a rule, in the case of very large projects, where the amount necessary for completion is indefinite or a very long time is required. In many instances the work extends over a long period, because the necessary plant or equipment must be collected gradually, and the work, if hastened too rapidly, becomes unnecessarily expensive. In these cases, as well as in others, a large discretion as to time of completion is necessarily left to the executive department, which can carefully consider all phases of the situation and secure such prosecution of the work as will be most beneficial to all concerned.

IV.

THE PROPER DIVISION BETWEEN APPROPRIATIONS BY THE FEDERAL GOVERNMENT, ON THE ONE HAND, AND BY THE STATES, MINOR POLITICAL DIVISIONS, AND INDIVIDUALS, ON THE OTHER HAND.

Numerous propositions have been made for a change of policy by Congress, so that the expense of river and harbor improvements shall be divided between the Federal Government and States, cities or communities, and individuals. Widely different policies have been adopted by various countries in the making of river and harbor improvements. It is difficult to draw any exact line in the classification of these policies, but, roughly speaking, it may be said that there are three methods employed:

1. That under which these improvements are left to individual or local enterprise, with the right to impose tolls upon the boats which

utilize them. This policy is best illustrated in Great Britain, where the improvement of inland waterways, such as canals and rivers, is, with few exceptions, prosecuted by private corporations or navigation companies. Harbors in this country are improved either by municipalities, as at Bristol and at Southampton, in the first instance, or by railway companies which desire seacoast terminals, or by dock and harbor boards affiliated with the city government, as at Liverpool. In all these cases the construction of docks, the dredging of channels, and the building of breakwaters are taken care of by the same company or agency. In practically all cases tolls are charged.

2. That under which the General Government prosecutes improvements and levies tolls. This is well illustrated by certain harbor improvements in France, where, in addition to the dredging of the channels, the Government provides docks and harbor facilities.

3. That in vogue in the United States, under which the General Government improves rivers either by open-channel work or by the construction of locks and dams, and charges no toll therefor, rendering navigation entirely free. Under this method in the United States there is likewise an improvement of harbors by the dredging of channels or anchorage spaces. Provision is also made for protection against the sea by breakwaters or otherwise. These improvements are not made the basis of a charge, though port dues are imposed, as in most, if not all, countries without regard to improvements made. This method, so far as it relates to canals and canalized rivers, was also adopted in France in the year 1879, and is still in vogue in that country, except as regards a considerable number of new works provided for in 1903 or later, under which there is participation in the expense, the General Government, as a rule, bearing 50 per cent of the cost and localities immediately interested the balance. In this case the localities which contribute money for the improvement are authorized to collect tolls for their reimbursement.

In our own country, until the time of the Civil War, no considerable amount was expended for the improvement of rivers and harbors. For the most part our rivers were neglected, and in many cases, as in Ohio, Illinois, and New York, canals were constructed at the expense of the State, though oftentimes with the aid of a grant of land from the Federal Government. Many canals were constructed by private companies. This class of improvements was regarded by one school of public men as outside the scope of the Federal Government, and for decades was vigorously opposed in many parts of the country. The constitution of the Confederate States of America, framed at Montgomery in February, 1861, in the enumeration of the powers of the general government, contained the following provision, which may be said to express one interpretation of the Federal Constitution on this point, as well as one view of the best policy to be adopted:

> To regulate commerce with foreign nations, and among the several States, and with the Indian tribes; but neither this nor any other clause contained in the constitution shall ever be construed to delegate the power to congress to appropriate money for any internal improvement intended to facilitate commerce except for the purpose of furnishing lights, beacons, and buoys and other aids to navigation upon the coasts, and the improvement of harbors and the removing of obstructions in river navigation, in all which cases such duties shall be laid on the navigation facilitated thereby, as may be necessary to pay the costs and expenses thereof.

In recent years there has been a noticeable lack of uniformity in the method of providing funds for these improvements. The State of New York in the year 1903, by popular vote, adopted a constitutional amendment providing $101,000,000 for a barge canal. In the year 1908 the people of Illinois, by the same method, voted an amendment to the constitution which allows the issue of bonds by the State to an amount of $20,000,000 for part of the expense of a deep waterway from the Lakes to the Gulf. In the original authority for the Chicago drainage canal provision was made that it might be a link in or part of a navigable waterway from the Lakes to the Mississippi River. At a very recent date provision has been made for a private canal in the State of Massachusetts, with a view to shortening the sailing distance and avoiding the dangerous passage in the open sea around Cape Cod. This enterprise contemplates the expenditure of private capital for the construction of the canal, also the charging of tolls. In numerous instances in other States, as in Oregon, Washington, Ohio, Pennsylvania, and California, provision has been made for waterway improvements, either independently or in cooperation with the General Government. Some municipalities have also voted large sums for harbor improvements. At the last session the Legislature of Texas passed a law (see General Laws of Texas, 31st Legislature, pp. 32 to 45) authorizing the formation of navigation districts, which districts may issue bonds, levy taxes, and condemn property in the prosecution of river and harbor works. At the last general election, in 1909, the people of Rhode Island authorized the expenditure of $500,000 for the improvement of Providence Harbor.

The commission finds that, in the development of waterways on a large scale, the decided tendency in other countries is toward a degree of participation by communities and localities especially benefited and is of the opinion that in order to obtain the best results this policy must ultimately be adopted in our own country. In the meantime, it is desirable to encourage participation by communities whenever their proposed improvements are worthy of recognition by the Federal Government. The objections to this plan of participation are that the necessity of including different localities and States in a single improvement would require a concert of action by numerous and perhaps varying interests, often impossible to obtain. This applies especially in the case of rivers passing through or by several States. Another objection is that less-deserving projects, presented with offers to furnish a portion of the cost, might obtain recognition to the exclusion of more useful projects for which less pecuniary support could be furnished. On the other hand, it can not be denied that in most instances river and harbor improvements confer an especial benefit upon portions of the country most nearly affected; that there is a constant danger of insistent pressure upon the Federal Government for the expenditure of money upon projects which have not been maturely considered, and which, if part of the burden were chargeable to the localities in which they are advocated, might not be presented to Congress. Again, in the accomplishment of any large and comprehensive plan for the full development of inland navigation throughout the country, and of the associated uses of water, the cooperation of all communities and interests is especially desirable. There is the further fact that terminal facilities are an integral part of any well-devised plan for waterway improvement.

These, at least, should be provided by the communities immediately benefited. It has been brought to the attention of the commission that in some instances heavy burdens have been laid upon traffic by exorbitant charges for the privilege of mooring at wharves owned by muncipalities or private individuals. There is a palpable unfairness in these cases, because the Federal Government is expected, without burden on the communities interested, to expend its money for river and harbor improvements, while the communities themselves show no disposition to cooperate, and, in a measure nullify the benefits secured by the large Federal expenditures.

In passing from this subject the commission would recommend:

1. That in the improvement of rivers and harbors similarly situated, where equitable division is possible, uniform rules be observed for a proper division of cost between the Federal Government and minor political divisions. There is at present a lack of uniformity. One illustration of this is in the improvement of interior channels and harbors. In some cases the expense is borne exclusively by the Federal Government and in other cases by the municipalities interested.

2. That participation in improvements by local communities be encouraged, always with due care to avoiding the adoption of projects which are unworthy of recognition by the Federal Government.

3. That improvements not essential to navigation should not be undertaken by the Federal Government.

4. That improvements in rivers and harbors be not made unless sufficient assurance is given that proper wharves, terminals, and other necessary adjuncts to navigation shall be furnished by municipal or private enterprise and that the charges for their use shall be reasonable.

V.

THE RELATION OF WATERWAY IMPROVEMENTS TO BANK PROTECTION, FLOOD AND DROUGHT PREVENTION, IRRIGATION, AND DRAINAGE.

In providing for the future development of the country, consideration must be given to the fact that water, as well as land, is an asset which makes up an integral part of our natural wealth. Waters must ultimately be utilized not merely for navigation, but also for irrigation and for power, when available for these purposes; also, all practicable means must be used for their clarification and for the prevention of floods and droughts.

It is desirable that whenever navigation is improved the most careful attention be given to these other associated objects, and while it is not the opinion of the commission that waterway improvements for the development of navigation should be deferred until a comprehensive and final plan for the utilization of waters can be devised, on the other hand subjects pertaining to the control and most beneficial utilization of water should at all times be considered, and improvements looking to the promotion of navigation should, as far as possible, harmonize with the general uses and beneficial control of waters. The subject of water power receives separate attention under heading VII of this report. Irrigation projects are now provided for by separate legislation under an act of Congress passed in 1902. All reasonable means for the prevention of floods should be utilized. Water when uncontrolled becomes a most destructive agency.

One of the most injurious of its effects is in the erosion of banks, which varies greatly with the periodical changes in river level and which is usually greatest during high floods or during their subsidence. It should always be borne in mind that the waterway improvements made by the Federal Government under the exercise of its authority should be restricted to navigation. Whenever bank protection or flood prevention or the clarification of water is the sole object of improvements, the question presents little difficulty in its solution. Such projects are not a proper charge upon the Federal Treasury. A more difficult problem, however, is presented where the improvements just mentioned have as their object both navigation and the protection of private property. In such cases, in the opinion of the commission, the expense should be apportioned between the Federal Government and communities directly interested. In many instances proposed improvements have as their main object the protection or benefit of private property. In such cases there is a distinct benefit conferred upon individuals or localities which is only of a remote or very indirect benefit to the country as a whole. Lands subject to periodical overflow or lands of uncertain value because of the danger of erosion, when improved, are multiplied many times in value, and there is a constant danger that such improvements will be advocated under the guise of river and harbor legislation framed to benefit navigation, when the real object is the benefit which will accrue to individuals or localities.

Beginning in 1902, river and harbor acts have provided that the protection of banks should not be appropriated for out of the National Treasury unless the improvement is required in the interest of navigation. The levees upon the lower Mississippi are an apparent exception to this rule, but when the construction of these levees was first undertaken by the Federal Government they were regarded as necessary for navigation and as an essential feature in securing a proper regimen for the Mississippi River. The question whether they are an aid to navigation is one which has been much discussed, some stating that they promote navigation and others that they do not, the prevailing opinion being that they have a direct effect upon the maintenance of the channel and an indirect effect upon navigation. In any event, more than half of the cost of these levees constructed since the time when the Federal Government commenced to have part in their construction has been borne by the States or communities bordering upon the river. Drainage projects can be advantageously prosecuted in conjunction with navigation improvements. The prevention of overflow during floods is helpful to navigation, though not essential to its existence. The line should, however, be carefully drawn between improvements which, in whole or in part, are for the protection or development of private property and those which are made in the sole interest of navigation.

Measures must ultimately be taken to permit and facilitate the greatest possible protection of property abutting on navigable and nonnavigable streams. It is desirable for the proper conservation and utilization of the resources of the country that these valuable lands should be protected. The commission would, however, repeat in this connection the recommendation made in No. IV, that improvements by the Federal Government be restricted to those essential to navigation, and would also recommend that, whenever a project is

under consideration or is in operation under which a very considerable amount of land will be reclaimed or protected from overflow, a survey be made and report be submitted as to the cost of the reclamation features of such project and as to the probable quantity and value of the land which would be reclaimed or benefited thereby.

VI.

POLICY RELATING TO HARBORS, INCLUDING THE OWNERSHIP AND CONTROL OF WHARVES AND DOCKS.

The question of the improvement of harbors, as a general proposition, presents little difficulty. The liberal policy heretofore pursued by the Government in this regard has greatly benefited the public and has resulted in a great increase in wealth to the country at large. The harbors so far improved have furnished outlets for our exports and made the products of immense areas in the interior readily available for shipment abroad or for use at home. They have been useful both to the foreign and coastwise trade, and made possible the entrance of boats of the deepest draft, thus greatly diminishing the rates of freight on ocean shipments. In addition, the construction of breakwaters and other means for the protection of the available space within numerous ports of the United States has served a most beneficent purpose in the more adequate protection of human life. These ports have as feeders not only the river systems and canals of the country, but also its great network of railways. It must be conceded that in comparing the benefits conferred by harbor improvements with those of river improvements, the former have been more uniformly helpful, though in some instances the appropriations for river and lake channels have brought an equal or even greater return than usually results from expenditures upon harbors.

The commission recommends the continuance of the progressive policy which has been adopted relating to harbors, but would advise a division of harbors into classes by depth or by the importance of their ocean or coastwise traffic. The greatest channel depth, which now is 30 to 40 feet, is not required save in great entrepôts of commerce, in the development of which it is probable that even greater depths than those now required may in time become necessary. Uniform and reliable channels, which can be depended upon for a certain depth and width from year to year and at all times, are the first essential.

The commission recommends care in avoiding an undue multiplication of ports; that is, it is undesirable to have three or four minor harbors insufficiently developed in a locality where one well-improved port will serve the purpose. Under the stress of local demands harbors have in some instances been improved where the money could have been more economically expended in the better development of those already in existence.

In recommending the improvement of harbors on a liberal scale the commission calls attention to the necessity for rendering them useful to the largest possible number, and thereby preventing a monopoly of benefits by a few corporations or individuals. Instances are not lacking in which the land suitable for terminals adjacent to improved harbors is owned by one corporation or by a comparatively small num-

ber of individuals. If improvements should be considered desirable where the number of water-front owners is small it is advised that a condition be carefully imposed to the effect that wharfage facilities shall be made available to the public generally, and that the charges for the same shall be submitted to the Secretary of War or other official for his approval.

It is also recommended that a proper dividing line be drawn between the work to be done under appropriations by the Federal Government and that by cities and individual owners. Provision for a safe entrance into a bay or harbor sufficient to afford safety to shipping and suitable anchorage grounds in proximity to cities thereon is the full duty of the Federal Government. Minor channels leading to wharves in harbors as well as upon rivers should be provided by communities or individuals.

The construction of wharves and docks by the Government has been advocated; but the commission is unwilling to recommend such a policy. In the first place, the total expense of harbor improvements would be greatly increased, and under such a policy money which might be expended for general purposes would be used for work that should more properly be left to municipalities or private parties. In deciding whether a harbor improvement is to be adopted or not, it is wise to omit those cases where there is not assurance that local or private enterprise will furnish all needed terminal facilities.

VII.

RELATION OF WATERWAY IMPROVEMENTS TO WATER POWER.

The commission has had under consideration the use of water power in connection with the development of navigation, as well as plans for the utilization of power and the right of the Federal Government to control or use the same.

The subject of water power is not within the scope of the inquiries of the commission, except as it is associated with navigation. The members, however, have given much attention to this general subject and strongly recommend the greatest care in the conservation of water power for the use of the people. Its value has not been fully understood, and power derived from navigable and nonnavigable streams will undoubtedly be developed to a much greater extent in the future and for a larger variety of uses. The commission especially recommends such legislation by Congress and by the States as would prevent monopoly in the possession of water power, and secure, to the greatest possible degree, its utilization for the general benefit.

The rights of the Federal Government in water power may be viewed from three different standpoints:

First. Cases in which power is developed on streams located in public lands, where undoubtedly the Government, so far as the rights pertaining to abutting ownership are involved, has full control, and should exercise the greatest care in granting away whatever rights it may have.

Second. When power is developed in nonnavigable streams, where there is a private or State ownership, in which case no Federal authority to regulate or control exists, except to prevent interference with the navigation of other streams.

Third. When water power is developed in navigable streams. In this case several plans have been proposed for the collection of tolls upon the water power developed by dams whenever their construction is permitted by Congress. The right of the Federal Government to collect such tolls must rest on one of three theories:

1. That the Federal Government has some proprietary right in the waters of navigable streams, so that the collection of tolls can be based upon actual ownership of, or right in, the waters.

2. That, as the right to grant or withhold consent for the construction of a dam in navigable waters rests in Congress, it is allowable to make a charge for the consent or privilege and authorize the collection of tolls.

3. That the Federal Government in its jurisdiction of interstate commerce has control of navigable streams and has a certain degree of responsibility for their improvement. Under this theory it is maintained that tolls upon the water power developed can be collected and paid into a fund for the improvement of navigable streams, including not only the one on which the toll is charged, but all others capable of improvement for navigation.

The commission is of the opinion that the Federal Government has no proprietary right or interest in navigable waters which would authorize the collection of tolls. The right, if it exists at all, rests upon either the second or third theory stated. As regards the second theory, it should be said that the imposition of tolls, unless based upon a more substantial foundation than the mere authority to grant or withhold consent—an authority arising solely from the control of the Federal Government for the purposes of navigation—does not commend itself to the commission, and it is to be doubted whether, even in case a bill should be passed or other action taken by Congress for granting this permission, with a provision for charging tolls, such tolls could be collected. Regarding the third theory stated, it should be noted that under the exercise of the taxing power Congress can levy taxes for general revenue purposes upon all classes of water power, whether in navigable or nonnavigable streams, and if charges are to be imposed it would seem that this is the normal method. It should further be borne in mind that a requirement for the imposition of tolls where the right to construct dams is hereafter granted would cause a discrimination between water power to be utilized under future permits and those already enjoyed, which are subject to no such charge. It must, of course, be remembered that whenever the privilege of constructing dams is granted in a navigable stream there is an undoubted right to impose charges sufficient to pay the expenses of examination and supervision and to secure the Government against cost by reason of obstacles to navigation created by the erection of dams; but this rests upon an entirely different principle from the proposal to charge tolls.

The control of the Federal Government over navigable streams has to do with navigation only, and in the exercise of this jurisdiction the plan commends itself to the commission of inserting in each grant or franchise under which the consent to construct a dam is given a condition that the grantee who constructs the dam must also, whenever necessary to subserve the interests of navigation, construct a lock suited to the locality and to the probable development of traffic, and also furnish power for the proper operation of the lock or locks. These

requirements, rather than the imposition of tolls, appeal to the commission because they are free from legal objections and are in entire accordance with the objects for which the Federal Government has jurisdiction over navigable streams.

Whenever the Government constructs dams for purposes of navigation or irrigation, and, as an incident thereto, water power is developed, such power should be utilized and an adequate charge made therefor.

The commission would call attention also to another important step in the control of water power, namely, that before the right to construct dams in any navigable stream is granted there should be a careful survey of the whole stream, or at least of that portion the regimen of which will be affected by the proposed construction. In the development of water power there is danger that dams will be located or constructed in such a manner as not to accord with the most helpful development of navigation.

The commission accordingly recommends that whenever permission to construct a dam in a navigable stream is requested consent shall not be granted until a survey has first been made and the proper location of dams has been determined.

It may also be stated that it is the opinion of the commission that if constitutional authority therefor exists a provision should be inserted in these grants giving to the Secretary of War or other official the right to regulate charges for power furnished to consumers.

A provision reserving to Congress the right to alter, amend, or repeal should be inserted in every act granting water-power rights.

VIII.

METHODS IN THE IMPROVEMENT OF RIVERS, INCLUDING THE CONSTRUCTION OF LOCKS AND DAMS.

The general course of river improvement for purposes of navigation in both Europe and America is, briefly, as follows:

1. A river survey.
2. The removal of trees, snags, and other accidental obstructions.
3. The straightening, deepening, buoying, and lighting of the natural channels.
4. The revetment of banks to stop their erosion and the construction of levees to prevent outflow over the banks.
5. The regularization of the open river, or the standardizing of its bends, its cross sections, and its water slopes, obtained by longitudinal dikes which direct the water flow and form new banks, by spur dikes which determine the channel and regulate the water flow, and by occasional submerged cross dikes which protect the bed of the river from excessive erosion, and maintain general river slopes.
6. The canalization of the river, obtained by the use of dams converting the river into a series of deep-water pools, and by the use of locks or other means of raising or lowering boats from each pool to the adjacent one.

The last two steps are often alternative propositions.

Such a plan of improvement is being followed on nearly all the navigable rivers of England, France, Belgium, and Germany, about half of which have already been carried through the entire programme.

In all the above stages of improvement the United States has little to learn from Europe in methods.

The Mississippi River from St. Paul to the mouth of the Missouri is a good example of a river which, from its moderate slope, good low-water discharge, and moderate high-water discharge, is capable of an excellent natural open-river navigation for light-draft boats; which can easily be regularized for medium-draft boats; or which can be canalized for boats of any draft. From the mouth of the Missouri River to the Gulf, the Mississippi, with its large low-water and large high-water discharge and mobile bottom, can be regularized, though engineering difficulties render the cost per mile greater than any other river work in the Mississippi Valley system. But it can not easily be canalized. The Ohio River, on the other hand, on account of its small low-water discharge can not easily be regularized for even light-draft boats, although it can be canalized for medium drafts.

Regularization of a river to give a good open-river navigation is only practicable on rivers with a gentle slope of river bed and a large low-water flow compared with a freshet flow, such as the Mississippi River below St. Paul, the Missouri River below the Yellowstone, the lower portion of many of their tributaries, the Hudson, the lower portion of the Atlantic and Gulf rivers in America, and in Europe the Rhone, Garonne, Durance, Loire, Lower Meuse, Rhine, Weser, Elbe, Lower Oder, Vistula, Nemel, Danube, Dneiper, Volga, and the tidal portions of other rivers; but even in these cases, on the lower and most favored parts of the Rhine above the Dutch frontier, and the middle parts of the Danube, the low-water flow has neither justified nor secured a low-water channel depth of over 3 meters (9.8 feet), nor of over 2 meters (6.6 feet) on the other European rivers, and on some of these rivers only as much as 1 meter (3.3 feet). A greater depth will probably require canalization. However, these depths, combined with the free, open river circulation, a perfected boat service, and fine terminal facilities, have on the German rivers led to an enormous tonnage of water traffic. North American rivers, as a general rule, surpass European rivers in length, in depth, and in water flow. The Rhine and the Danube are the only rivers in Europe, outside of Russia, with a greater low-water flow than the upper Mississippi River above the mouth of the Missouri.

Whenever the river slope is too steep and the corresponding current too great to be easily ascended by ordinary tows, and an open-river navigation is still preferable to canalization, the boat service is sometimes maintained by the aid of special chains or cables, laid under water along the bottom of the river, by which the boats pull themselves upstream. The use in Europe, however, of cables or chains is diminishing rather than increasing. In the United States there are but few places where this system would be useful.

Where the river slope is steep or the low-water discharge is small or where a draft greater than practicable by open-river methods is desired, the river improvement is usually best obtained by canalization.

The movable type of dam is the one most common in river canalization work, its great advantage being that it lies flat on the river bottom during high waters and opens the entire river to free navigation as long as the high water continues.

The earliest and most persistent type of lock and that still most generally used everywhere is the ordinary masonry lock, composed

of two masonry side walls, closed at each end by movable doors or gates, the resulting inclosure or chamber being furnished with valves and passages by which it can be filled with water from the upper pool and can discharge its water into the lower pool.

When the boat traffic is very great and the highest pool of a river receives but little water from its tributaries, the lack of proper water supply may limit the river traffic and require either a change of lock construction to some other type using less water or else a pumping plant. A desire to economize water, combined with a desire to hasten the passage of boats through locks, is the main reason for the substitution during recent years of inclined railways or "canal inclines" and vertical lifts for the masonry lock. But the tendency of to-day in Europe seems to be toward retaining the masonry lock type, unless the conditions of dam location and of boat traffic are exceptional. In this connection, attention is invited to the fact that a high masonry lock is being built alongside of the Henrichenburg pneumatic lift on the Dortmund-Ems Canal, in Germany, and the hydraulic apparatus of the Anderton lift on the Weaver River canals near Liverpool, England, has recently been replaced by mechanical counterpoises and electro-dynamic machinery. There seems to be no good reason, therefore, for changing the existing practice in the United States, which is slow to give up the use of masonry locks.

Where a considerable height is to be overcome by masonry locks, there is usually a choice between the use of several locks of small lift and a lesser number with larger lifts. The present tendency is toward larger lifts.

In the matter of construction details, the European locks seen by the commission, while interesting as parts of the river improvement system, contained but few features not already in use in the United States.

There are many reasons why open river navigation is preferable to a lock and dam or canalized navigation; among others, the capacity for practically unlimited traffic, easier travel during freshets, and very much greater speed of boat travel, especially downstream. One great recommendation of open river navigation is its relative economy. Canalization is almost always very expensive, both in first cost and in subsequent operation, so that its adoption must assume a reasonable certainty of great water traffic over the improved route.

While the growth of traffic may eventually demand with propriety either the thorough regularization or canalization of all navigable waterways, there are always in every country, and especially in the United States, many streams whose water slopes, water flow, character of banks and bed, etc., will render thorough improvement by either method above described too expensive to be justifiable from an economic standpoint.

IX.

COMPARISON OF EUROPEAN WATERWAYS WITH THOSE OF THE UNITED STATES, INCLUDING AN INVESTIGATION OF EUROPEAN AND AMERICAN TRANSPORTATION RATES BOTH BY LAND AND BY WATER.

A majority of the commission made an inspection of European waterways in the months of August, September, and October, 1909, visiting expecially England, France, Germany, Holland, Belgium,

Austria, and Hungary. Typical harbors, as well as most of the important rivers and canals of these countries, were examined, and numerous conferences were held with the engineers and other officials having them in charge. In practically all these countries waterways have attained a high standard of development. This is due both to the fostering care of the states or political subdivisions and to private enterprise. In Germany, especially, and in fact in all countries except England, the increase of inland water-borne traffic has been marked, as shown by the following table, compiled from Volumes VI and VII of the Reports of the British Royal Commission on Canals and Waterways, recently published:

Tonnage of European waterways.

[In 1,000 metric tons.[1]]

Country.	1875	1880	1888	1905	Percentage of increase.	Average annual increase.
England and Wales[2]			33,124	32,340	−2.4	−0.14
France		18,000		34,030	89.0	3.6
Germany[3]	20,800			103,400	397.0	13.2
Belgium		24,836		53,345	114.0	4.5

[1] The total tonnage for these countries is calculated by adding together total receipts and shipments, but since this method is uniformly employed the percentages of increase are reliable.
[2] Excluding sea-borne traffic on the Manchester Ship Canal.
[3] The tonnage of some minor streams is only estimated.

The great increase in water-borne traffic in Germany shown in the table above is mainly upon her important rivers. In 1875 the seven main rivers carried 60 per cent of the total traffic and in 1905, 80 per cent. On the Rhine alone between Kehl and the Dutch frontier 43 per cent of the total traffic was carried, and on the Elbe between Hamburg and the Austrian frontier 24 per cent was carried. The total length of free and canalized rivers and of canals in several European countries is shown by the following table, compiled from Volume VI of the Report of the Royal Commission on Canals and Waterways:

Classification of waterways.

[Length in miles.]

	Principal lines.			All waterways.
	Free rivers.	Canalized rivers.	Canals.	
England and Wales	812.0	1,312.0	1,927.0	4,053
France	[1] 796.0	970.1	1,776.7	7,485
Germany	1,948.0	425.2	894.8	6,200
Belgium	74.5	307.0	334.2	1,015

[1] The Loire for 166 miles between Briare and Nantes is paralleled by a canal and is only used by small boats.

According to Part I of the Report of the Commissioner of Corporations on Transportation by Water in the United States (see pp. 28, 29), there are 295 navigable streams in this country having a navi-

gable length of approximately 26,410 miles. Forty streams, with a length of 2,600 miles, have a 10-foot navigation, and 70 more, with an additional length of 3,200 miles, have a depth of from 6 to 10 feet, during the greater part of the year. The Mississippi River and its principal tributaries alone have about 2,500 miles of 6-foot low-water navigation. There are at present in the United States 45 canals still in operation, with a length of 2,189.04 miles. Of these, 17 government canals aggregate 194.49 miles in length, 12 state canals aggregate 1,358.98 miles, and 16 private canals aggregate 635.58 miles. Hence the total length of all navigable rivers and canals in operation is about 28,600 miles.

Upon the Rhine, the most important inland waterway of Europe, the traffic has assumed enormous proportions, showing an increase greater than on any waterway of this country, except possibly the Great Lakes. In 1875 the average tonnage per mile upon this river for the 351 miles above the frontier of Holland was 1,560; by 1905 it had mounted to 11,400, an increase of 631 per cent. On the canalized portion of the river Main, one of the smaller tributaries of the Rhine, the traffic has increased from 296,000 total tonnage in 1887 to 2,552,000 in 1905. This enormous increase has taken place in spite of the fact that the Rhine at no place above the Dutch frontier is more than 10 feet deep at ordinary low water, and the depth of the Main is even less. The low-water depth of the Rhine is only 9.8 feet for 110 miles from the Dutch frontier up to Cologne; thence 8.2 feet for 82 miles to St. Goar; thence 6.6 feet for 79 miles to Mannheim; and thence 4 feet for 84 miles to Strassburg. The Main has a low-water depth of 7.5 feet from the Rhine for a distance of 26.5 miles to Offenbach; and only 2.6 feet for the next 217 miles to Bischberg.

The canals of all the European countries visited by the commission, except those of England, have shown in the aggregate a steady increase in traffic, although there are instances of abandonment or marked diminution. This increase has taken place on canals which, with few exceptions, are of shallow draft, the average depth being about 6 feet. In France the average annual increase has been about 3 per cent. This is in marked contrast to the record of canals of this country, which, except for a comparatively few ship canals connecting the Great Lakes, show a decrease of 73 per cent from 1880 to 1906. This decrease is partially explained by the fact that, since 1880, about 888 miles of canals have been abandoned.

The general policy of almost all European countries has been toward the development and improvement of their waterways, though of late years in a few instances projects already adopted have been abandoned or prosecuted without assurance of early completion. It is difficult to make reliable comparisons between the amounts expended for waterways in those European countries in which the General Government appropriates money for this purpose, and the amounts spent in the United States, partly because in Europe the expense of improvement is often shared by the state and the provinces, districts, and individuals affected, and partly because far greater amounts have been expended for wharves, ice harbors, local basins, and other facilities for harbors and river-borne commerce than is customary with us. Inland harbors especially are developed on a much more extensive scale in Germany, France, and Belgium than

in the United States. The city of Frankfort, for example, is now carrying out new harbor works, the cost of which, including land purchase will be approximately $17,640,000. The whole amount will be defrayed by the city without state aid.

From 1814 to 1900 the Government of France spent on inland waterways approximately $301,000,000 for improvement and construction (including levees, revetments, etc.), and over $148,000,000 for maintenance and heavier repairs. Belgium spent for the construction of state waterways from 1831 to 1905 about $77,000,000, and for current improvements and maintenance about $24,000,000. Between 1813 and 1906 Prussia spent for waterway construction and improvements about $129,000,000, and for maintenance in 1905 about $4,000,000. The congressional appropriations in the United States for the survey, improvement, and maintenance of harbors and waterways from 1802 to March 2, 1907, amounted to almost $553,000,000, of which sum about $69,000,000 were spent up to 1906 upon canals and canalized rivers. In an official document published in 1903 the relative amounts appropriated for rivers, harbors, and canals to and including December 31, 1902, is stated, namely, $221,869,759 for rivers, $147,448,903.32 for harbors, and $33,237,857.24 for canals. But it must be remembered that the United States is about eighteen times as large in area as either France or Germany, and the length of its navigable rivers and canals is nearly four times as great as in France and more than four times as great as that of Germany. In all these cases what the central governments have appropriated for waterway improvements is only a part of the total amount expended. In the United States, for instance, about $214,000,000 have been spent upon canals by States and corporations.[1]

The increase of traffic on the waterways of Europe in contrast with the decline on many streams of the United States is due, in part at least, to the very great difference between conditions in Europe and those in the United States, of which the following are, it is believed, the most important.

1. *Difference in density of population.*—The United States is much less densely populated than Europe. In 1909 the population was estimated at 46 inhabitants per square mile for the entire United States, while for entire Europe it was approximately 107. In Germany the population is 290 per square mile, and in Belgium it is 620. The greater density of population in Europe tends to increase the quantity of freight in a given area, though this statement must be made with some limitations, due to the lower average of consumption and the less degree of industrial activity in some parts of Europe. At the same time it is a notable fact that the railway mileage per square mile in the United States, at least in the settled portions, is equal to or greater than that in Europe, while the entire mileage per thousand of population is five times as great, thereby showing that the United States is much more adequately furnished with means for railway transportation.

2. *The earlier development and greater relative advantages of waterway systems in Europe.*—In Europe the waterways were developed and in very general use before the introduction of railways. Factories as well as warehouses were located with reference to such waterways,

[1] Census Report, Transportation by Water in 1906, p. 44.

and great reliance was placed upon waterway transportation as a means of industrial growth. The European waterways were constructed in many cases at a time when the question at issue was only between transportation by wagons and by boats, and consequently the European railway systems constructed at a later date were not developed to the same degree of efficiency as those in America. It is also more difficult to provide railways in Europe because of the very high cost of rights of way; and in this connection the opportunity for betterments in the way of eliminating grades and curves is much less in Europe than in America. The carrying capacity of the European freight car is but a fraction of that in the United States.

3. *Trade movement.*—Another difference as compared with the United States is the greater fixedness in Europe in the location of manufacturing cities, as well as in the lines of distribution of raw material due to the earlier development of coal mines and other sources of material. The shifting of the centers of production which arises from the development of new coal mines and new centers of manufacturing, as well as from the great growth of population, is much less common in Europe than in the United States. This makes it possible to utilize an established waterway with a greater assurance of profit and with greater dependence upon it as a means of transportation.

4. *Habits and customs.*—One social condition, entitled to very considerable weight, is the existence in Europe of a class of boatmen who, for generation after generation, apply themselves to the handling of boats in river or canal traffic. These boatmen live with great economy upon the canal boat and seem to be contented with comparatively small gains and with conditions which would not be regarded favorably in the United States. In most cases towage is accomplished by horses, which are often stabled in the boats, but in numerous instances canal boats are towed by men. Steam and electric traction is restricted mainly to larger boats and trains of tows.

5. *Engineering difficulties.*—Engineering difficulties, as a rule, on those rivers which are most utilized, are less serious on the rivers of Europe than in the United States. The most notable example of this is the River Rhine. Its sources are in the Alps, where the melting of snow and ice during the hot weather of summer furnishes a constant supply for the water flow of the river at the very season when rivers are likely to be lowest in the United States. Furthermore, it should be said that conditions as regards alluvial banks, and shifting bars due to deposits of silt, are on the whole more favorable to river improvement in Europe than in the United States, and especially so upon rivers whose improvement would be most useful.

6. *The different relations between railways and waterways.*—Military considerations have been much more regarded in Europe, not only in the construction but in the management of transportation lines, than in the United States. Railways are laid down to connect the center with the frontier, or, at any rate, are located with a view to the mobilization of troops and to the carrying of supplies to places where they may be needed, and with a less uniform regard for serving great manufacturing centers or populous cities. Waterways are located mainly with a view to the development of trade at all times and to relieving the railroads in time of war.

Sedulous care is taken by most European countries for the protection of inland water-borne traffic against railway competition. In France this is accomplished by enforcing a differential of 20 per cent in favor of the waterways as against railways, with the evident intention of maintaining both methods of transportation. In a majority of the other countries in which water transportation has reached its highest development the railways wholly or partially belong to the State. This is true in Germany, Austria, Hungary, Holland, and Belgium. The well-established policy in these countries is to secure cooperation between railways and waterways by official control of railway rates, with a view to maintaining profitable traffic on the latter. The following tables, compiled from Volume VI of the Report of the Royal Commission on Canals and Waterways, show the comparative mileage and the comparative tonnage of the railways and waterways of Belgium, France, and Germany:

BELGIUM.

Year.	Length (in miles).		Tonnage (in 1,000 tons).	
	Waterways.	Railways.	Waterways.	Railways.
1888	998.4	2,364.7	24,836	40,352
1890	1,018.2	2,378.4	25,242	42,990
1895	1,009.7	2,407.8	30,242	46,664
1900	1,015.6	2,881.2	38,178	55,108
1903	1,015.6	2,874.4	49,020	59,297
1905	1,015.6	2,873.8	53,345	65,319

FRANCE.

Year.	Waterways (miles).	Railways (miles).	Waterways (1,000 tons).	Railways (1,000 tons).
1880	6,782	14,315	18,000	80,774
1885	7,676	18,500	19,573	75,192
1890	7,670	20,634	24,167	92,506
1895	7,614	22,469	27,174	100,834
1900	7,533	23,436	32,446	126,830
1903	7,589	24,149	33,340	129,305
1905	7,483	24,459	34,030	139,000

GERMANY.

Year.	Waterways (miles).	Railways (miles).	Waterways (1,000 tons).	Railways (1,000 tons).
1875	[1] 6,200	16,430	20,800	167,000
1885	6,200	22,940	27,600	200,000
1895	6,200	27,780	46,700	331,000
1900	6,200	30,750	73,000	487,000
1905	6,200	33,730	103,400	588,700

[1] Although new waterways, with a length of several hundred miles, have been constructed since 1875, other waterways, aggregating about the same length, have entirely lost their importance and are therefore excluded, so that the total length is accepted as unchanged. If all abandoned or insignificant lines are included, the total length of German waterways may be estimated at from 7,709 to 8,500 miles.

In 1906 the length of the railways of the United States was 222,571 miles, about 7.7 times the estimated length of all its navigable canals and rivers as given on page 28. The total tonnage of the railways in 1904 amounted to 1,631,374,219 tons. This was 12.3 times the estimated traffic of all the navigable rivers and canals in the United States, amounting to 132,000,000 tons.[1]

The success of water transportation in Europe is often attributed to the fact that railroad rates are higher abroad than in the United States. In a later report the commission will endeavor to set forth

[1] W J McGee, Our Inland Waterways, in Popular Science Monthly, April, 1908.

a careful comparison between the freight and passenger rates of European countries and those of the United States. Frequent errors have been made in the past in comparing the average rates per ton per mile, owing to the different methods of handling traffic and of determining rates, resulting in erroneous and confusing conclusions. In Belgium, for instance, the cost of collection and delivery is included in the railroad rate, while in England such freight as is carried by express companies in this country is carried by the railroads directly. The average length of haul in this country is far greater than in Europe, owing, in some measure, to the smaller political divisions abroad. This tends to reduce the average cost per mile in this country. A proper comparison must be between specific commodities carried for specific distances, and under similar regulations as to the method of handling, and must take into account the comparative cost and effectiveness of labor, and also the cost of materials used, in the two cases.

Moreover, the railroads of Europe realize a much larger share of revenue from passenger traffic. Consequently, on the majority of their lines a greater degree of attention is paid to the handling of fast passenger trains, and this necessarily diminishes the efficiency of freight service. It has been stated in a document transmitted to the commission that the average time during which a freight train is operated in Prussia is only three hours per day, the cars being on sidetracks and in yards the remaining twenty-one hours. It should be conceded in this connection, however, that in some cases the efficiency of freight service and the number of hours of actual running time per day is no greater in the United States than in Europe.

While recognizing the necessity of more thorough investigations of the results of all these different factors, the commission would call attention to the fact that the average European freight rates on railway lines paralleling water routes, especially for short distances, are higher than those on lines similarly situated in the United States, and also that the European rates for water-borne carriage, in some instances even where the traffic is very large, are as high or higher than on railways in the United States in localities where traffic is likewise large.

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MEMORANDUM OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS IN CONNECTION WITH E. D. 7288 AND CIRCULAR LETTER OF JULY 27, 1909, BASED THEREON, RELATING TO CAUSES OF DECLINE OF WATER TRANSPORTATION.

[Transmitted by the Chief of Engineers.]

In considering the causes which have led to the decline of water transportation, where it has occurred, a decline is deemed to exist not only in those cases in which records of tonnage show an actual decrease, but also in those in which the records show an increase not in proportion to the increase in the general commerce or business of the community.

An example of the latter class is furnished by the coal shipments by water to Cincinnati, which have not increased in proportion to the consumption of coal in that city.

The prevalent cause leading to the decline of water transportation is without doubt the railroad. The railroad corporation of large resources and facilities for its business successfully competes with navigation companies or individual boats with limited resources and facilities; and, competing, naturally does not enter into such relations with its competitor as to increase the business of the latter, declining to prorate, or to recognize through bills of lading. Moreover, railroads have established rival boat or barge lines through which competition has been discouraged. (Delaware and Raritan Canal, controlled by Pennsylvania Railroad; Allegheny Valley Railroad; Long Island Sound by both Pennsylvania and New York, New Haven and Hartford Railroads; and generally on Atlantic and Pacific coasts and Great Lakes.)

The lower boat transportation rate does not measure the cost of water transportation. To it must be added charges for wharfage, teaming, and insurance; boat transportation on smaller streams is characterized by exposure of merchandise to the elements while on the bank awaiting or discharged from, the boat; shipments transferred to or from rail routes must be handled in detail; time schedules, affecting passenger traffic deranged often by low water and at times by high, are frequently uncertain; freight, on the contrary, is often delivered more quickly by water; capacity of boats may be insufficient to provide transportation as needed; recompense for damages to freight in transit difficult to determine in amount or to collect.

Enumerating the above serves to accentuate the advantages of rail transportation even at a higher first cost. In place of wharfage charges, and exposure of merchandise to the elements, is the railroad freight house, or it may be the car on a siding, minimizing or even abolishing teaming. Carloads are transferred from one line to another without handling of freight; less than car loads, without teaming. Increase in freight is met by increase in cars; time schedules are independent of water stages as a very general rule.

But water transportation must contend with not only the greater facilities of rail, but also with rail rates so low as to make movement of freight by water unprofitable. Water competition renders imperative what is well know as the long and short haul clause; and rail rates to meet such competition paralyze water transportation. The boat line bankrupted, the rail rate may be raised, for the water competition is no longer actual but constructive only. The rail rate itself is not necessarily unreasonable; it is held to be destructive and in restraint of trade when so low as to cause a loss to the railroad company. There may be cases, though none is known, where a rate has been held to cause a loss; though but one case is known where a rate to an inland point involving much shorter haul than to a water point has been declared unreasonably high by comparison with the rate to the water point, even though the latter rate cause no loss to the railroad company.

Railroads have also caused a decline in water transportation by centering such transportation about special points with greater facilities, natural and artificial, for greater vessels. Examples of this are to be found on the New England coast; and farther south, Norfolk has displaced Richmond and West Point. And here it may be fitting to note that water transportation has its fullest development on the Great Lakes and in the waters of and along the coasts of the United States when forming links in a chain of joint rail and water traffic.

But the essence of this fullest development is a capacious water way; and this develops another cause for the decline—the intermittent character of the work of improving waterways. Contrast the improvement of the Ohio River with the construction of the Panama Canal. Both works are covered by comprehensive plans for definite results; but for the canal, appropriations are limited only to the extent of their possible due use.

But having in mind the Mississippi River, it does not appear that when navigable depths are available, they would be utilized to the extent of the greatest possibilities afforded. Streams are not used to their fullest or best advantage. The demand is often for greater depths, instead of adapting draft of boats to prevailing depths. Once lower competitive rail rates have been secured, traffic is diverted to the railroad, but in such cases the object desired by the community—the reduction of cost of transportation—has been secured.

Causes of local decline more or less widespread, yet well defined, are exhaustion of lumber (several localities); falling off of mackerel (Maine); abandonment of special manufactures, as salt and flour (Muskingum River); substitution of artificial for natural ice (a few localities); decline in use of "brown stone" (Connecticut River); demand for cotton by local factories (Savannah River).

In one case decline is in part due to a large industrial corporation declining, except in isolated cases, to ship its products by water (Ohio River).

In substituting the above memorandum, it is desired to invite attention to the fact that so far as data examined show, there has been no case where decline has been due to failure of the works of the department to produce improvement in navigable capacities when requisite funds have been supplied.

THE DEVELOPMENT OF SEAPORTS AND INTERNAL WATERWAYS.

THE NAVIGATION OF THE YANGTSE AND THE AMAZON.

[By Admiral C. S. Sperry, U. S. Navy.]

In discussing the proper development of commercial harbors and their facilities and the symmetrical development of the tributary internal waterway systems, it is advisable to consider, first, the development of the ocean carrier which is in progress and the conditions by which it is governed, recollecting that the same conditions do not govern the development of vessels navigating sheltered and narrow inland waters or rivers with strong currents and sharp bends. River boats and light-draft barges of great beam, singly or in tows, can navigate such waters more safely and economically than a vessel built on the lines of an ocean carrier.

The necessary characteristics of the most economical ocean carrier can not be better stated than by quoting from a paper on "Maritime commerce, past, present, future," by Elmer Lawrence Corthell, M. A. Dr. Sc., civil engineer, read before the American Association for the Advancement of Science, August, 1898:

Draft of water for the steamships of the present and future is the desideratum to which urgent attention should be called by all those who desire the continued development of commerce and the still further cheapening of transportation and a greater reduction in prices.

I can not state this important condition that confronts us any better than in the words of one of the leading naval architects of the world, Dr. Francis Elgar, the consulting naval architect of the Great Fairfield works on the Clyde, and the designer of the *Campania* and *Lucania*. In a paper entitled "Fast ocean steamships," read before the Institution of Naval Architects in 1893, not long after these ships were built, he used these words (the italics are our own):

"Deep draft of water.—This is a most important element of speed at sea, and it is now strictly limited by the depth of water in the ports and docks used by the fast passenger steamers on both sides of the Atlantic. Twenty-seven feet is the extreme limit of depth to which a ship can load on either side. The *Campania* can not load an inch deeper than the *Umbria*, although she is 100 feet longer. If the underwater dimensions of *Campania* had been increased proportionately to those of *Umbria* her draft of water would have been 32½ feet. This class of steamer is increasing in length and breadth, but the draft of water has to be kept the same. The result is that it is only a question of time, and not of a very long time with our present materials of construction and type of propulsive machinery, to find an absolute limit of speed imposed by the restriction of draft of water.

"It is not only that the present limited draft of water will finally impose an absolute limit of speed, other conditions remaining the same, but it has already a very prejudicial effect in keeping down speed at the point actually reached. If the draft were not restricted, the form of section could not be improved by giving to it more rise of bilge and an easier curvature. * * *

"As the displacement is increased by increase of draft, the power required to drive a ton of displacement at a given speed becomes reduced. Hence increase of draft does not mean a proportionate increase of engine power, even when such increase is obtained merely by extra immersion without any improvement of form such as would otherwise be possible.

"The advantages of increased draft would be felt still more in a seaway than in smooth water, as the lower part of the hull would be less affected by the wave surface and better and more constant immersion could be given to the propellers. * * *

"The Atlantic trade is increasing at such a rapid rate that larger and swifter ships are certain to be soon called for. The depth of water has lately been somewhat increased at Liverpool; but much deeper harbors and docks will be required if further great increases of speed at sea are to be obtained without excessive difficulty and cost. * * *

"The opinion of practical navigators and of commercial men handling large vessels is that the inability to provide the depth of channels and harbors necessary to increase the draft of large freight carriers is very detrimental to good navigation and economical transportation.

"As vessels increase in size they have to be built as flat as possible to allow them to enter the harbors, which injures their sea-going qualities and renders them more dangerous and unwieldly, as well as more liable to injury from their shape * * *."

It appears from these statements that, as the displacement of an ocean carrier is augmented by increasing the draft and other dimensions symmetrically, the power required to drive a ton of displacement at a given speed is reduced, which lessens the necessary expenditure for coal and operating force per ton of cargo carried. A modern ocean carrier of 5,000 tons displacement requires 1,000 indicated horsepower to drive her at a speed of 10 knots, and a carrier of the same type symmetrically enlarged to 10,000 tons displacement requires only 1,587 horsepower to drive her at the same speed; that is, the cargo-carrying capacity is doubled at the same speed with an increase of little more than 50 per cent for fuel. The increased expense for labor is less than 1 per cent and the superiority of the large carrier in adverse weather is very marked. A small light-draft steamer in rough water is thrown about by every wave; her way is deadened by pitching into a heavy sea and her engines are always in danger of breaking down, owing to the racing of the propellor as her stern rises out of the water. Consider also that both the small ship and her cargo are liable to serious damage by heavy rolling and the shipping of water on her low decks, and the reason why the tonnage of the ocean carrier increases so steadily and keeps so close to the available depth of water at the harbor entrance is sufficiently apparent.

Lloyds Register of British Shipping shows that in 1893–94 there were only 87 steamers of and above 5,000 tons, while in 1908–9 there were 599, and during the same period the steamers of 3,000 tons and above 2,000 tons decreased in number from 1,277 in 1893–94 to 1,013 in 1908–9. The eagerness with which the size of steamers follows the available depth of water is shown by the fact that the White Star Line is now building the *Olympic* and *Titanic*, with a draft of 37½ feet on a displacement of 60,000 tons, to take advantage of the new 40-foot channel into the port of New York.

The report of the Chief of Engineers, United States Army, 1907, states that the lowering of freight rates at Boston during the last 15 or 20 years has been about 50 per cent, and that the deepening of the harbor of Savannah has lowered the rates at that port from 30 to 50 per cent. A memorandum supplied by the Savannah Chamber of Commerce in November, 1909, states that the increase in the size of ships at that port, owing to the increase of the depth of the channel to 22 feet at low water, has been 40 per cent in the last 10 years, and that during the same period marine insurance has fallen 25 per cent and freight rates 37 per cent.

The very great economy of the large ocean carrier sufficiently explains the activity with which such great ports as New York, Liverpool, London, Shanghai, and a host of lesser ports are being improved

the world over, while the great ship canals, Suez and Kiel, are being steadily deepened; but it is evident that long lines of canals, or even such rivers as the Amazon and the Yangtse, owing to the great labor involved, can not be improved commensurately, and therefore the most economical long-distance ocean carriers can never use them. Nor, conversely, can even the largest of the vessels using our inland waters, deepen and improve the waterways as we may, ever navigate the high seas economically or safely as compared to an ocean carrier of to-day of even moderate proportions.

Certain artificial waterways will always be used even though the size of vessels navigating them may be, to a certain extent, limited, and to this class belong the Suez and Panama Canals.

The Suez Canal, 87 miles in length, shortens the route for the vast commerce from northern and western Europe to Calcutta by 3,700 miles and to Hongkong by 3,300 miles, as compared to the routes by the Cape of Good Hope and the Straits of Sunda; and although vessels now using the canal are limited to a draft of 28 feet the canal is being deepened to take vessels drawing 31 feet, and even the greater economy of the larger freighter will not justify the expense of the longer voyage around the Cape. The same conditions make it certain that the Panama Canal, 49 miles long, with a designed depth of 41 feet, will be used by ocean carriers. The west coast of South America is in the same longitude as the Atlantic seaboard of the United States, and, with trifling deflections about Cuba, the course from New York to Callao is nearly a straight line. From New York to Callao via the Panama Canal the distance is 3,400 miles. From the entrance to the English Channel to Callao by the same route it is 6,500 miles. From the channel to Callao via the Straits of Magellan it is 10,100 miles. From New York to San Francisco via Panama the distance is 8,050 miles less than via the Straits of Magellan. The trade route for large carriers from Europe to Valparaiso may continue through the Straits of Magellan, because of the great ports of call on the east coast of South America, but the trade of the northern ports on the west coast will inevitably pass through the canal, and that short and cheap route for vessels of the largest class must develop a great trade between the east coast of the United States and the west coast of South America. The fertilizer nitrates and other products of the coast should come north in exchange for the lumber, manufactured cotton, and other goods and coal of the Atlantic States.

The considerations which force the use of the Suez and Panama Canals are manifest.

The Kaiser-Wilhelm, or Kiel Canal, connects the North Sea with the Baltic, and is 53 miles in length. The saving in distance for vessels bound from the English Channel to the Baltic is about 200 miles and the navigation of the narrow waters about Denmark is avoided. The canal can now take vessels of the largest class, but is being still further deepened in view of the increasing size of war vessels. The principal motives of the German Government in building the canal were undoubtedly military and strategic, the commercial aspect being incidental. The least depth of water encountered by vessels passing into the Baltic through the Great Belt, or route to the north and east of Denmark, is 36 feet.

The total number of steamers, barges, and sailing vessels carrying cargo, or in ballast, using the Kiel Canal, and their tonnage, are

given in the Great Canals of the World, Department of Commerce and Labor, 1895 to 1904, and in Statistiches Jahrbuch für das Deutsche Reich, edition of 1909, for remaining years, as follows:

Year.	Number of vessels.	Tonnage.
July 1, 1895, to June 30, 1896 (the first year after opening)	16,834	1,505,983
1898	23,108	2,469,795
1900	26,279	3,498,767
1902	30,161	4,285,301
1904	32,038	4,990,287
1906	34,187	6,045,963
1908	34,121	6,012,178

The Corinth Canal, connecting the Gulf of Corinth with the Gulf of Aegina, is less than 4 miles long and shortens the voyage from the Adriatic by 170 miles, and from the Mediterranean by 100 miles, but the Mediterranean Pilot, B. A., fourth edition, page 51, states:

None of the foreign steamship companies navigating the Mediterranean now use the canal. It is mostly used by small Greek passenger steamers.

It can be navigated by vessels not drawing more than 23 feet 6 inches, but, owing to the troublesome winds and currents and the narrowness of the channel, the use of one or two tugs is necessary, even for steam vessels, to keep them from grounding. These drawbacks account for the little use made of the canal, and it is well to consider the general conditions under which large vessels navigate canals. If the draft of the vessel approaches very near to the limit fixed by the depth of the channel, the suction is so great, owing to the little water between the ship and the bottom of the canal, that the vessel will obey the helm very sluggishly and sometimes not at all, even if there is neither wind nor current, and an instant off the course in a narrow channel will put the vessel aground. The propellers are very likely to be damaged under such circumstances, which is a serious matter for the ship, and if the vessel continues aground for any length of time the traffic on the canal is tied up and the loss to all parties is very heavy. Such accidents add to the expense of operating the canal and must be considered in adjusting the tolls, and as they also add to the ship's expenses they must be considered in rates of freight and insurance.

In regard to such canals as the St. Marys, connecting Lake Superior with the chain of lakes to the east and south, it is obvious that, as there is no alternative, vessels must use them, and owing to the economy of large vessels many of them are of such size that for a portion of their route over connecting waters of the Great Lakes there is at times no more than 6 inches of water to spare—so narrow a margin is only possible in tideless waters with little seasonal variation in height, and the possibility of poor steering is contemplated and met by additional care because of the conomy of the larger vessel or barge.

The Welland Canal through Canadian territory takes vessels drawing not more than 14 feet, and with a length of 26¾ miles has 26 locks. It is the only available water route between Lakes Erie and Ontario; but the great body of the traffic on Lake Erie being destined for the middle and eastern United States naturally proceeds by rail or through the Erie Canal, thus lessening the traffic through the Welland Canal.

A canal from Chicago to Toledo, via Fort Wayne, would be about 250 miles in length, and the passage via the Straits of Mackinaw between the same points is about 700 miles, but it seems certain that large lake carriers would not use a canal between those points. The speed of a large carrier could not possibly exceed 5 knots, less than half the speed in open water, unless the depth were more than 3 feet greater than the draft of the vessel, and the power required to drive a large vessel in a canal is so greatly increased by the suction that there soon comes a point where the speed is practically constant, however great the power expended. Also, the danger of grounding in the case of a large carrier steering badly in shallow water and causing delays and blockade is very considerable. Any use of the canal except for local traffic by barges would probably be exceptional.

The traffic in certain canals of no great length, which permit ocean carriers of more or less limited draft to reach important commercial centers, shows some increase, as in the case of the Manchester Canal, 35½ miles in length, with a least depth of 28 feet, and the Bruges Canal, 7 miles in length, with a least depth of 26 feet. (Port of Manchester Official Sailing Ship List Guide, July, 1909, p. 90, and North Sea Pilot, B. A., 1909.)

The sea-borne traffic of the Manchester Canal in 1898 was 2,218,005 tons, and in 1905 it was 3,993,110 tons. (Royal Commission on Canals and Inland Navigations, Vol. IV, 1908, p. 80.)

At Bruges the number of vessels entering in 1900 was 101, tonnage 30,785 tons; in 1905 it was 151, tonnage 49,022 tons; and in 1908 it was 576, tonnage 321,067. (Tableau General du Commerce Etranger, Belgium, 1908, p. 692.)

The limit of the use of most canals by ocean carriers is speedily reached, but the particular conditions are local and various. In the North Sea and the English Channel the sea portion of the route rarely exceeds 12 hours, and the economy of the carrier of limited size making the continuous voyage lies in the fact that one handling is saved by proceeding direct to such a port as Bruges, but if the canal is long the delays of navigation, ordinary or due to casualties, are such that transshipment with proper terminals will be speedier and more economical.

The Seine has been so improved that Rouen is practically the seaport of Paris. The distance from the outer limit of the estuary of the Seine to Rouen is 71 miles, and vessels drawing 19 feet can ascend to that place at high-water neap tides, and vessels drawing 25 feet can ascend at high-water springs. The size of vessels frequenting the port is increasing. In 1905, 1,482 vessels, with a tonnage of 1,051,562 tons, entered the port. (Channel Pilot B. A., 1906.)

NAVIGATION OF THE YANGTSE.

The navigation of the Yangtse is at all times difficult, and pilots who travel the river constantly are a necessity, as the changes are so frequent that charts can not be depended on. In summer when the river is high the banks are generally flooded and the strong current makes navigation dangerous. When the river has subsided the channels are completely changed, and shoals and bars have formed and new passages have been cut through where none existed.

The highest water occurs between June and October, and the height of the summer above the winter levels may be considered to be for Chinkiang, 190 miles from the sea, 15 to 18 feet; Kiukiang, 450 miles from the sea, 30 feet, and for Hankau, 600 miles from the sea, 40 to 50 feet. At the highest water, in July and August, the higher portions of the river have the appearance of an immense lake, and at many places between Nanking and Hankau the waters exceed 20 miles in width. Sometimes no land can be seen from the deck on either hand as far as the distant hills.

The great treaty port of Shanghai lies on the Wusung River, which enters into the Yangtse about 20 miles from the sea, and is about 12 miles above the mouth of the Wusung. The entrance to the Yangtse is obstructed by bars and flats and heavy vessels can only enter at high water. Neaps ordinarily rise 10 feet and springs 14 to 15½, so that in ordinary weather vessels drawing from 26 to 30 feet may enter according to the state of the tide, but the tides are greatly affected by the winds, and with a strong wind from the westward, they are much lower. The extensive bar at the mouth of the Wusung is another obstacle; but usually vessels drawing 21 feet can reach Shanghai in the autumn, and drawing 24 or 25 feet in the spring. This necessitates lightering cargo at the Wusung bar, in many cases, as very large steamers frequent the port.

Shanghai is one of the chief commercial cities of the world. The population is about 350,000, of which 7,000 are foreigners in the settlements. In 1905, the total foreign imports at Shanghai were valued at £38,863,144, and the exports to foreign countries at £16,238,508. In the same year 5,156 vessels, with an aggregate tonnage of 7,195,000 tons, entered the port. In addition there is a large inland steam navigation trade. About 6,000 tons of coal and 4,000 tons of liquid fuel are usually in stock. For 50 miles around the city there is water communication with the interior in every direction by the numerous canals and creeks which intersect the Province. There are numerous wharves where any vessels that are able to cross Wusung inner bar can lie alongside.

Nanking, 230 miles from the sea, can be reached at all times by vessels drawing 27 feet if they have been able to cross the bar at the entrance to the Yangtse.

Hankau, 615 miles from the sea, is the highest point of any direct foreign trade, of which there is no great amount, what there is being principally oil steamers of the Standard Oil Co. The bulk of the trade is by river steamers carrying cargo transshipped at Shanghai. There are eight lines of such steamers, affording daily communication. From June to October vessels drawing 27 feet can reach Hankau, but for the remainder of the year access is occasionally difficult for vessels drawing as little as 9 feet. At Hankau the river is a mile wide and during the summer it is inconvenient for vessels to lie far out, as the strong current makes communication difficult. Vessels are liable to the danger of being fouled by timber rafts, which sometimes during freshets break adrift from the banks higher up, where they are moored.

Ichang, about 980 miles from the sea, is the head of river-boat navigation for unbroken voyages, as above that point the Yangtse passes through narrow gorges and is obstructed by rapids. There is no direct foreign trade. Many river steamers not drawing more

than 6 feet ply to Ichang, and there are about 12,000 junks for handling cargo transshipped for upriver trade.

At none of the towns above Shanghai on the Yangtse are there any wharves, nor are there any facilities for handling cargo except a plentiful supply of cheap coolie labor.

The latest type of river steamers on the Yangtse is a triple-screw steel steamer 250 feet long with 40 feet beam, and drawing, with an average load, 5½ feet. She is one of four steamers trading regularly from Hankow to Ichang and is supplied with a steam launch to precede the steamer and take soundings. Another steamer, the *Kiang Hsiu*, belonging to the China Merchants Co., is 325 feet long, 44 feet beam, draws about 7 feet, has twin screws, and was built in 1905. The first river steamers on the Yangtse were American side-wheel boats sent out for the purpose, but of late years the new screw boats of steel have been built at Shanghai. (Information principally from the China Sea Directory, B. A., 1904, Vol. III, and Supplement, 1907.)

Great plans for railway development in China, which have been debated for many years, seem about to be realized, in a measure, and they will doubtless stimulate the development of the hill country beyond the reach of the great canal system of the Yellow River, but Shanghai will continue to reap the benefit of the great canal and river system of which it is the center. It will be benefited very greatly if the Woosung bars are dredged to take vessels drawing 27 feet at all seasons—27 feet being nearly the maximum draft which can usually cross the bars at the entrance to the Yangtse, which are so wide that their improvement is not likely to be undertaken. The wharves of Shanghai at which vessels can lie already extend for several miles on both banks and can readily be greatly extended, so that as the channel is deepened shipping will be favored by the terminal facilities and still fewer ocean carriers will care to meet the strong currents and difficult navigation of the Yangtse.

NAVIGATION OF THE AMAZON.

The city of Para lies in the estuary of the Amazon and it had a population in 1899 of 120,000 people. In 1901 the exports, principally rubber, isinglass, cocoa, hides, nuts, tobacco, and deerskins, were valued at $14,000,000.

The following account of the port facilities of Para is taken from the weekly Hydrographic Bulletin, No. 1048, issued by the United States Hydrographic Office, Navy Department, September 29, 1909:

> *Para, Brazil.*—The entrance to the port is marked by the lightship and gas buoys; there are 21 feet on the bar at low water. The harbor is a good one, with a least depth of 20 feet, but the holding ground is poor. Pilots are necessary and are reliable; the charges are high. The chart used was the British Admiralty chart, a late issue; it is reliable. A limited amount of repairs to vessels' engines and dynamos can be made. Moderate-sized castings can also be made. There is one floating dry dock; no wrecking appliances. There are no wharves. Cargo is handled with ship's gear, and the lighters are good up to 200 tons. Labor is negro, plentiful and cheap. Fresh and canned provisions can be obtained; the price is high. River water is used for drinking and boiler purposes. There is a hospital. There is telegraphic and rail communication to Bahia. There is a fair quantity of coal on hand; it is handled by lighters alongside. The money used is Brazilian; the rate of exchange fluctuates. No time or signal service. (From information furnished the Branch Hydrographic Office, New York, Aug. 23, 1909, through the courtesy of Mr. W. Leddin, chief officer of British steamer *Hyanthes*.)

It will be noted that the draft of vessels entering the port must be limited to about 20 feet, which restricts the ocean carriers at Para to a tonnage of about 2,000 tons, as appears from the following memorandum on the trade on the Amazon, prepared from the latest information available by Capt. A. G. Winterhalter, United States Navy, hydrographer:

Steamers drawing 14 feet can navigate the Amazon for 2,700 miles above its mouth, or to Borja, 400 miles beyond Iquitos, Peru. The principal difficulty is due to the shifting bars, the strong currents, 3 to 5 knots, and the immense quantity of driftwood which comes down when the river is rising. Pilots are necessary and are regularly employed by companies operating river steamers.

Manaos, about 900 miles from the mouth of the river, is the most important town above Para, and has both ocean and river trade. There is about 40 feet difference between high water and low water at this point.

From Manaos to Iquitos, Peru, about 1,300 miles, there are no towns of importance. The difference between high and low water is about 18 feet at Iquitos.

The following regular lines of steamers are engaged in the commerce of the Amazon:

Amazon Steam Navigation Co.—Twenty-nine steamers, of 9,184 aggregate tonnage, ply between Para and points on the Amazon and tributaries.

Booth's Line.—Thirteen steamers, from 1,100 to 2,000 tons each. Itineraries of these vessels include the following ports: Manaos, Liverpool, Havre, Lisbon, Madeira, New York, Maranhao, Ceara, and Barbados. Smaller vessels of this line go to Iquitos. Sailings every 10 days from Manaos for Europe; every 20 days for New York.

Red Cross Line.—Nine steamers; aggregate tonnage, 9,467. This line has same itinerary as Booth Line, dates of sailings alternating with those of latter line.

Lloyd Brazilian Line.—Seven vessels, of 1,999 tons each, plying between Manaos and Rio Janeiro, and touching at intermediate points.

Ligure Brasiliana (Italian).—Two steamers, plying between Manaos and Genoa, touching at Para and Mediterranean ports.

A. Berneaud & Co.—Twelve steamers, of 150 to 300 tons each, navigating the Amazon, Madeira, Negro, Purus, and other tributaries.

In addition to the above there are many river steamers owned by the rubber firms of Para, Manaos, and Iquitos. These firms have from one to eight steamers each, according to the extent of their business, engaged in taking up supplies to the rubber gatherers and bringing down cargoes of rubber. There are, perhaps, as many as 150 vessels of this description on the Amazon and its tributaries. There are no telegraph lines in the valley, nor communication of any kind other than by water. Efforts are being made to lay a cable from Para to Manaos. Communication between the upper Amazon and the Pacific is slow and difficult. From Iquitos to Lima requires about 30 days, 20 of which are by mule.

Manaos had a population of 40,000 in 1900 and is the terminus for the lower river steamers of the Amazon Navigation Co. In places above Para the river, although very deep, is only 38 yards wide from bank to bank, which, with a current, makes navigation by large vessels difficult and dangerous.

Iquitos, Peru, is distant, as the crow flies, about 540 statute miles from the nearest point of the west coast of South America, and about 400 miles from the crest of the Andean watershed, which, between 4° south and 8° south, has a general height of about 6,500 feet. The Peruvian Government is projecting railways from the coast into the Andean region, and in view of the comparatively short voyage from the west coast via the Panama Canal to the Atlantic States, it is probable that the whole trade of Peru as it develops will take ship from the Pacific coast rather than go via the Amazon and Para. The distance from Callao to New York via Panama is 3,400 miles. From the head of navigation on the Amazon to Para there are 2,700 miles of difficult river navigation, and from there to New York by sea the distance is 2,943 miles.

There seems to be no question that both on the Yangtse and on the Amazon the tendency is to handle traffic in river steamers of such

light draft that they can work at all stages of the river, fast, easily handled, and capable of making river landings safely.

It may be said generally that the decrease in ocean freight rates is very great, as the size of the carrier increases; that at the great seaports, where cargoes are ample, the largest carriers which can enter will be employed, and that the system of internal waterways should be improved as rapidly as possible to supplement the railroads, but that transshipment at the seaport being a commercial necessity, however the goods may reach the port, development will be in vain unless ample terminal facilities are provided, so situated as to permit of indefinite expansion.

THE COMMERCE OF THE HUDSON RIVER.

[By Mr. E. O. Merchant.]

The commerce of the Hudson River consists principally of lumber, grain, ice, building materials, including brick, also fuel, including coal. There is also an extensive passenger and excursion traffic.[1] There has been a falling off in traffic since 1899, due partially to the decrease in ice shipments, the competition of railroads, and the decline of canal traffic. The total receipts and shipments for 1906 were estimated at 8,654,880 tons, of which 1,335,615 tons, or 15.5 per cent, were miscellaneous merchandise.[2]

Commerce on the Hudson River at Albany.[3]

	General merchandise.	Total.	Percentage of merchandise.
	Tons.	*Tons.*	
1898	697,554	4,045,895	17.2
1899	730,809	5,070,800	14.4
1900	1,037,389	4,810,927	21.7
1901	776,908	3,123,409	24.9
1902	297,323	3,673,097	8.1
1903	546,527	3,486,419	15.7
1904	632,205	3,513,545	18.0
1905	256,846	3,310,628	7.8
1906	314,952	3,325,360	9.5

[3] Transportation by Water, Pt. II, pp. 69, 70.

In 1906 the total traffic at Albany was divided into the following percentages:

Ice	23.6
Lumber and timber	16.3
General merchandise	9.5
Vegetable food	10.6
Stone, cement, sand, etc	12.6
Fuel (wood and coal)	12.3
Miscellaneous	15.1

The most complete statistics of the local commerce of the Hudson are those collected by the United States Army engineers for the stretch of the river between Coxsackie and the State dam at Troy. These show that the amount of freight traffic here has declined

[1] Transportation by Water, Pt. II, p. 69.
[2] United States Census Report on Transportation by Water, p. 208

nearly one-third within the last decade, while the passenger traffic has increased slightly. The variability of the figures for general merchandise, especially from 1900–1902, is due partially to the lack of uniformity. Beginning with 1902, manufactures and sundries were listed separately. Before this they were probably included in general merchandise. It was stated by the engineers that during the years 1898–1900, the total commerce on this section of the river amounted annually to more than 10,000,000 tons.

Local river commerce between Coxsackie and State dam at Troy.[1]

	Total.	General merchandise.	Percentage of merchandise.	Passengers.
	Tons.	*Tons.*		
1898	4,045,895	809,746	20.0	771,196
1900	4,810,927	1,037,389	21.6	1,567,600
1901	3,123,409	776,908	25.0	1,293,236
1902	3,673,097	297,323	8.1	1,078,648
1903	3,486,393	546,527	15.7	1,044,254
1904	3.513,545	632,205	18.0	1,117,785
1905	3,310,628	256,846	7.8	1,222,473
1906	3,325,360	314,952	9.5	1,300,297
1907	2,881,168	435,640	15.0	1,266,008
1908	2,945,921	477,983	16.2	1,288,721

[1] Compiled from annual reports of Chief of Engineers.

THE MOVEMENT OF PACKAGE FREIGHT ON THE GREAT LAKES.

[By Mr. E. O. Merchant.]

No exact statistics are available for the movement of package freight through the Great Lakes, although some general idea can be arrived at by an examination of the figures for general merchandise, miscellaneous freight, miscellaneous merchandise, and unclassified freight. Package freight correspounds roughly to what is meant by general merchandise, and is included, as a rule, in the statistics given for the miscellaneous and unclassified freight, so that it is safe to say that in no case would the percentage of package freight be greater than the percentage of these several classes, and more often it would be considerably less.

The great artery of lake commerce is the route from Lake Superior through the St. Mary Canals, Lake Huron, St. Clair River, St. Clair Flats Canal, which is a channel at the upper end of Lake St. Clair, St. Clair Lake, and the Detroit River to Lake Erie. Over this route passes the enormous shipments of iron ore eastward, and coal westward. In comparison with the shipments of these two commodities, the relative amount of package freight is very small, though in number of tons it is fairly large, as the following table will show. Careful statistics are collected by the United States Army Engineers at the Sault Ste. Marie Canals and these give the best index of the amount of traffic passing over this main route. The American Canal, built by the State of Michigan, was opened in 1855. It has twice been enlarged by the United States Government, so that since 1896 it has permitted the passage of vessels of 20 feet draft. The Canadian Canal, constructed by the Canadian Government, was opened in 1895. The following table shows the amount of general merchandise and

the total traffic passing through these canals since 1885 for seasons ending December 31:

Canals at Sault Ste. Marie.[1]

Year.	General merchandise.			Total shipments, eastbound and westbound.	Percentage of general merchandise.
	Eastbound.	Westbound.	Total.		
	Tons.	*Tons.*	*Tons.*	*Tons.*	
1885	....	....	184,963	3,256,628	5.7
1890	....	....	371,294	9,041,213	4.1
1895	....	....	463,308	15,062,580	3.1
1900	86,333	455,064	541,397	25,643,073	2.1
1901	79,723	478,318	558,141	28,403,065	2.0
1902	122,248	617,852	740,100	35,961,146	2.1
1903	92,486	567,353	659,839	34,674,437	1.9
1904	95,374	636,635	732,009	31,546,106	2.3
1905	100,357	736,226	836,583	44,270,680	1.9
1906	150,586	984,265	1,134,851	51,751,080	2.2
1907	106,075	916,579	1,022,654	58,217,214	1.8
1908	110,238	732,663	842,901	41,390,557	2.0
1909	163,159	977,185	1,140,344	57,895,149	2.0

[1] Compiled from the annual reports of the Chief of Engineers and the Monthly Summary of Commerce and Finance.

The following are the percentages of the principal commodities passing through the Sault Ste. Marie Canals in 1907:[2]

Commodity.	Per cent.	General direction.
Iron ore	68.0	Eastbound.
Coal	19.6	Westbound.
Flour, wheat, and other grains, of which 5.1 was wheat	8.0	Eastbound.
Lumber	1.9	Do.
Salt, pig iron, copper, etc	.7	
General merchandise	1.8	East and west bound.[3]
Total	100.0	

[3] Of the traffic in general merchandise in 1907, 89.5 per cent was westbound and 10.5 per cent was eastbound.

The total eastbound shipments through these canals average four times the westbound, owing to the enormous iron-ore traffic.

No statistics of traffic passing through the St. Clair Flats Canal and Detroit River are collected, but the number of vessels and their registered tonnage are recorded, from which, by a comparison with the statistics of St. Marys Canals, estimates of the total traffic and value thereof are computed. The amount of traffic passing through the Detroit River averages from 25 to 28 per cent greater than that through the Sault Ste. Marie Canals. The traffic through the St. Clair Flats Canal averages somewhat less than through Detroit River, which is to be expected, since Lake St. Clair and the head of Detroit River absorb much more Lake Erie coal coming through Detroit River than they do Lake Superior ore coming through St. Clair River and the Flats Canal.

[2] Transportation by Water, Part II, pp. 208-211.

The following table shows the domestic traffic passing through the Detroit River for the last three years. The totals are somewhat smaller than those for both domestic and foreign.

Domestic traffic through Detroit River.[1]

	Miscellaneous.[2]			Total shipments southbound.	Total traffic northbound.	Total all shipments.	Percentage of miscellaneous.
	Southbound.	Northbound.	Total.				
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	
1906[3]	966,738	1,303,042	2,269,780	44,129,343	16,448,812	60,578,155	3.7
1907	1,053,090	1,299,766	2,352,856	46,966,193	20,326,311	67,292,504	3.5
1908	1,402,900	1,011,683	2,414,583	29,260,914	17,685,970	46,946,884	5.1

[1] Monthly Summary of Commerce and Finance, December, 1908, the tonnage being estimated as that passing a point near the center of Detroit's water front.
[2] The figures for general merchandise and package freight would be somewhat smaller.
[3] Only totals are obtainable before this date.

Lake Erie stands first among the Lakes, both in volume and value of its total traffic. At its ports are received practically all the grain and flour shipped to American ports and nearly 80 per cent of the iron-ore movement, and from Lake Erie ports are sent the great bulk of coal shipments. While primarily a lake of receiving ports, the coal shipments and miscellaneous package freight bring the volume of shipments on Lake Erie above those on Lake Michigan.[4] At a majority of the Lake Erie ports it appears that the receipts of general merchandise exceed the shipments, and it also appears that there is an extensive interchange of general merchandise between ports; Cleveland, especially since 1902, seems to be the most notable exception, as the following table will show. At Sandusky, Ohio, and Buffalo the shipments of general merchandise also somewhat exceed the receipts.

Lake commerce at Cleveland.

Year.	Merchandise and other articles.			Total receipts.	Total shipments.	Total receipts and shipments.	Percentage of merchandise.
	Received by lake.	Shipped by lake.	Total.				
	Tons.	*Tons.*	*Tons.*				
1895	65,464	94,374	159,838	3,593,044	1,608,313	5,201,357	3.0
1896	53,315	99,121	152,436	3,475,281	2,047,285	5,522,566	3.0
1897	76,680	134,809	211,489	3,623,001	2,378,347	6,001,348	3.5
1898	78,439	161,488	239,927	4,038,684	2,461,834	6,500,518	3.7
1899	60,216	142,743	202,959	4,769,720	2,621,201	7,390,921	2.9
1900	113,671	142,749	256,420	4,820,597	2,548,826	7,369,423	3.5
1901	66,219	168,563	234,782	5,410,277	2,089,817	7,500,094	3.1
1902	74,024	722,405	796,429	5,799,420	3,059,603	8,859,023	9.0
1903	88,161	638,451	726,612	5,240,828	3,518,985	8,859,813	8.2
1904	84,353	596,694	681,047	4,477,172	3,841,738	8,318,310	8.2
1905	90,742	615,974	706,716	6,749,262	3,494,866	10,244,128	6.9
1906	89,181	615,769	704,950	5,575,473	3,807,111	9,382,584	7.5

The following tables, compiled from the annual reports of the Chief of Engineers, show the domestic commerce at Duluth. The percentage of general merchandise to total receipts and shipments is very small, as shown by the first table. The reason for this is the predominance of coal in the receipts and of iron ore in the shipments, as shown by the second table.

[4] Transportation by Water, Part II, pp. 233 and 234.

Domestic commerce at Duluth.

	General merchandise.			Receipts and shipments—all commodities.	Percentage of general merchandise.
	Received.	Shipped.	Total.		
	Tons.	*Tons.*	*Tons.*		
1900	112,230	52,996	165,226	7,089,441	2.3
1901	115,644	41,187	156,831	6,851,729	2.3
1902	[1] 142,267	45,496	187,763	9,175,593	2.0
1903	[1] 122,447	34,625	157,072	9,002,530	1.7
1904	[1] 96,954	29,248	126,202	8,024,319	1.6
1905	[1] 129,484	35,749	165,233	13,139,541	1.3
1906	[1] 154,030	42,235	196,265	16,518,200	1.2
1907	[2] 242,481	[2] 49,139	[2] 291,620	[2] 34,786,705	.9
1908	[2] 194,785	[2] 34,743	[2] 229,528	[2] 23,797,162	1.0

[1] Includes about 2,500 tons of fish. [2] Duluth and Superior combined.

Domestic receipts and shipments at Duluth.

	1900	1901	1902	1903	1904
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Receipts	1,234,119	1,248,526	1,291,357	1,599,402	1,617,581
Coal receipts	958,286	955,427	905,915	1,281,930	1,350,544
Shipments	5,854,322	5,603,203	7,884,236	7,403,128	6,406,738
Iron ore	4,270,429	3,836,553	6,198,043	5,939,575	5,147,028

	1905	1906	1907	1908
	Ton.	*Tons.*	*Tons.*	*Tons.*
Receipts	1,755,501	2,094,099	7,840,023	6,594,915
Coal receipts	1,397,788	1,601,166	7,037,179	5,805,708
Shipments	11,384,040	14,424,101	26,976,682	17,202,247
Iron ore	9,766,815	12,498,033	23,590,969	14,064,633

The low percentage of general merchandise to total traffic along the main route from Lake Superior to Lake Erie is, in all probability, somewhat misleading as to the actual amount of this kind of traffic carried on the Great Lakes. There is an extensive local business on Lake Erie, as already indicated, and also on Lake Michigan, which can not be estimated. If we leave the main channel, the percentage of general merchandise rises at once, as the following tables show:

Portage Lake Ship Canal.[1]

	General merchandise.			Total up and down shipments.	Percentage of the whole.
	Bound up.	Bound down.	Total.		
	Tons.	*Tons.*	*Tons.*	*Tons.*	
1900	180,474	42,465	222,939	1,867,772	11.9
1901	124,389	19,480	143,869	2,114,385	6.9
1902	166,486	18,721	185,207	2,532,323	7.3
1903	166,737	15,723	182,460	2,420,848	7.5
1904	116,606	9,651	126,257	2,295,922	5.5
1905	163,107	20,559	183,666	2,462,910	7.4
1906	204,407	20,717	225,124	2,602,044	8.6
1907	164,967	19,492	184,459	2,496,336	7.4
1908	166,904	23,432	190,336	2,300,124	8.2

[1] Compiled from the annual reports of Chief of Engineers and the Monthly Summary of Commerce and Finance.

Traffic through Sturgeon Bay and Lake Michigan Canal.

	General merchandise.			Total, all commodities.	Percentage of merchandise.
	East.	West.	Total.		
	Tons.	*Tons.*	*Tons.*	*Tons.*	
1907	18,169	40,208	58,377	775,496	7.5
1908	19,242	36,474	55,716	692,613	8.0

METHODS OF FINANCING THE CONSTRUCTION AND IMPROVEMENT OF WATERWAYS IN EUROPE.

[By Mr. E. O. Merchant.]

BELGIUM.

Many of the Belgian waterways were constructed at an early period, so that the details of their construction are not always definitely known. At the beginning of the nineteenth century they were under French influence, and their present administration, procedure of obtaining funds, etc., is somewhat similar to the French system.

The total length of the Belgian waterways is 1,345 miles, of which 330 miles are of little importance. The total length of the main lines is 1,015 miles, of which 900 miles belong to the State and 115 to the Provinces, communes, or concessions.[1] During the period 1820–1830 there were 1,005 miles of waterways, of which 10 per cent belonged to the State, 64 per cent to the Provinces, 7 per cent to the communes, and 19 per cent to concessions. Shortly after this the State began to acquire the lines and buy up the various concessions, so that in the period 1860–1870 the State owned 83 per cent of the waterways, which then measured 1,220 miles. The Provinces owned 7½ per cent, the communes 4½, and concessions 5 per cent.[2]

At the present day, with the exception of a few lines constructed under concessions, the navigable waterways in Belgium may be considered as State owned. The important concessions remaining are:[2]

(1) The canalized Dendre, with Ath-Blaton Canal, owned by a private company.

(2) Rupel-Brussels Canal, owned by an association of the various communes along the line, in which the commune of Brussels has the largest financial interest.

(3) The Dyle-Louvain, owned by the commune of Louvain.

The inland harbors of commerce, ports, and wharves are owned and administered by the municipalities, Provinces, and communes, and in the mining and industrial districts by the interested parties. The harbors of refuge and some harbors of commerce, especially constructed, are owned by the State. The capital necessary for the construction and maintenance of the State waterways is provided out of the ordinary budget revenue. The expenditure was formerly largely met by tolls, which from 1840 to 1860 not only covered the cost of improvement and maintenance but also afforded a surplus for

[1] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 42. [2] Ibid, p. 47.

interest on the cost of construction.[1] The tolls have been considerably reduced since that time, but still cover a part of the cost of current improvements and maintenance, which in 1905 amounted to about $440,000, not including cost of personnel.[2] When the interest on the capital invested at 3½ per cent is added to the deficit from maintenance the total annual charge to the State is about $2,740,000.

FRANCE.

Up to 1879 the capital necessary for the construction and improvement of French waterways was provided by the State in various ways:

(1) From special loans raised for this purpose.

(2) From the ordinary revenues of the State.

(3) By giving the canals in concession to companies or private individuals who provided the capital.

The means for covering the expenses of interest and maintenance, etc., were obtained from tolls, which were of a very complicated nature until standardized in 1867.[3]

By the law of 1879 a program for nationalizing the waterways was inaugurated, improvements in the existing waterways were undertaken, and about 405 miles of new canals constructed.[4] Between 1879–1900 there was an annual expenditure of $5,741,880 for construction and improvements, and an annual expenditure of $2,189,700 for maintenance, not including the expenses of administration, which are debited to the State expenditure for this purpose.[5]

The capital required for the execution of this program was provided by the issue of 3 per cent Government bonds. All tolls were abolished in 1880, so that the expense of maintenance and of interest on the loans had to be borne by the State.

A new program regarding waterways was instituted in 1903 on the proposition of M. Baudin, the minister of public works. The works of improvement in the existing system are to be carried out entirely at the expense of the State, the cost being met by the ordinary resources of the annual revenue.

For the new works a law was passed laying down the following principles:[6]

(1) All parties concerned may be called upon to supply pecuniary help for simple improvement works on existing waterways.

(2) All parties concerned must contribute to a total amount at least equal to half the total expenditure for the construction of new waterways.

(3) All parties concerned who have contributed by subsidies to the new waterways may recoup themselves in whole or in part by obtaining the concession of certain tolls and of the monopoly of traction.

(4) The expenditure on the part of the treasury will be paid from the ordinary revenue of the budget. In no case will recourse be had to a loan or to a system of advances, the inexpediency of which experience has shown.

The maximum tolls which can be levied to cover interest and amortization are fixed. As soon as the debt is paid these tolls cease.

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[1] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 49.
[2] Ibid., p. 53.
[3] Ibid., p. 24.
[4] Ibid., p. 5.
[5] Ibid., p. 22.
[6] Ibid., p. 37.

In the case of two canals, Canal de Celte an Rhone and Canal de Marseille an Rhone, the chambers of commerce have undertaken to reimburse themselves for their share of the capital by tolls levied exclusively on the goods loaded and discharged at the ports of Celte and Marseille.

In the case of the Canal du Nord, the chambers of commerce have been authorized to levy tolls, and also to exploit a traction monopoly to cover the interest and amortization of the $4,800,000, which they have guaranteed to contribute.[1]

At the request of the minister of public works in 1908 the general council of the Ponts et Chaussees undertook an investigation of the further improvement and extension of the system of waterways in France.[2] The four points especially considered were:

(1) New works or improvements.

(*a*) Those included in the program of 1879, but not carried out.

(*b*) Those proposed, but not included in the program of the law of 1903.

(2) New works to be provided for.

(3) Lines of international traffic, or so-called lines of penetration toward central Europe.

(4) Ways and means of carrying on these works.

Subcommittees were formed and hearings arranged and the numerous documents submitted were examined. In its report the committee stated that the French waterways system in 1907 contained 7,376 miles, of which 3,035 miles were canals. This system is administered almost entirely by the State, only 158 miles now remaining in private hands. The estimates submitted by the committee were as follows:

(A) Improvements on existing lines:

1. Those not needed, approximately	$17,800,000
Of which the localities interested might contribute	3,600,000
And the State	14,200,000
2. Those less needed, about	13,400,000
Of which the localities interested might contribute	1,170,000
And the State	12,230,000
3. Those designated for future action	1,700,000

In making these improvements, since they were on existing lines, the localities are not, as in the construction of new works, required to contribute one-half of the expense. Consequently the State has to bear the burden, receiving only such assistance as is voluntarily contributed.

(B) For the construction of new lines:

1. Works of the first category; the Northeast Canal from Denain to Longuzon is estimated to cost about	$30,000,000
2. Works designated for future action are estimated to cost	50,000,000

If only the most needed works on the existing lines and the Northeast Canal are constructed, the cost to the State, which must furnish one-half of the cost of the latter, according to the principle laid down in 1903, will be about $29,000,000.

The problem is how to raise the money. Senator Audiffred proposed that canal concessions be granted to syndicates of chambers of commerce or of private persons who should raise funds by loans and

[1] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 38.
[2] The Report of the Committee on Navigable Highways (translated by Maj. Mahan).

should have the right to levy tolls in order to meet the sinking-fund charges and interest. If the revenue from the tolls was insufficient, the State should make up the deficit. This is the plan adopted in the building of railroads. The minister of finance objected to this proposal very emphatically, his argument being that methods which were satisfactory for financing railroads could not be applied to canals. The receipts from tolls would in all probability only be sufficient to pay the cost of maintenance and administration. The State, therefore, would have to bear the greater part of the annuity, and in the long run would be expending as much for annuities as it would have done for the construction of the canals in the first place. Furthermore, there would be a greater temptation to construct works which were not only not necessary, but which could not possibly yield a return on the investment.

Regarding the proposal for a system of the concessions without a guarantee of interest by the State, the minister of finance pointed out that it could only be put into practice in very rich districts, where there would be reasonable assurance of profit. Most of the necessary construction would never be undertaken.

Another objection against granting concessions of any kind raised by the commission was that it would seem rather irrational for the State to enter upon a policy of granting concessions just at a time when it had bought up nearly all of the existing ones.

The minister of finance also thought that in special cases, where the burden of providing one-half of the capital was too great for the interested parties, a mixed system might be proposed, where a less subvention should be demanded and the State be authorized to collect, on its own account, all or a part of the tolls during a certain number of years. The committee, however, did not view this scheme with favor, for the reason that it would reopen the levying of State tolls, abolished in 1880, and upset the present condition of competition in transportation by rail and water.

The recommendation of the committee is that the State continue to carry out directly the execution of the works with the assistance of those interested, this assistance amounting to about one-half for new works and for works already existing to be fixed by the special circumstances of the case. The parties interested are to reimburse themselves by means of tolls. It is also recommended that works of first importance should be completed within 15 years, and for this purpose the annual appropriation in the budget for this purpose be increased to $3,600,000. The commission is further of the opinion that traction monopolies should at once be formed which may be turned over for a period to the interested parties contributing toward the construction of new works, as a means of reimbursement in addition to the tolls.

GERMANY.

The year 1885 may be taken as the commencement of the improvement of the German waterway system. The uniform plan for the regulation of rivers in Prussia was formulated and sanctioned by the Landtag in 1879.[1] The canalization of the Main was begun in 1883 and completed in 1886; the original works on the Spree-Oder Canal

[1] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 57.

were carried out from 1887 to 1891. With few exceptions, the canalization of the rivers and the canals has been carried out by the several States, and they are State owned. The Teltow Canal, constructed and administered by the district of Teltow, is the most important exception.[1] The capital for constructing and improving the waterways is provided by the State in one of the following ways:

(1) From the current revenue in the State budget, section for "Extraordinary expenditure."

(2) By means of special loans.

(3) In certain cases, in combination with the contributions from Provinces, districts, communities, and other interested parties.

The manner in which the expenditure is divided between the State and the latter varies according to the conditions of each special case, taking into consideration the advantages accruing to the parties interested in the construction of the works. In certain cases the interested parties also bear the expense of the land purchase.

The construction of inland harbors is usually left to the municipalities, corporations, and other interested parties, who, as a rule, also own the sheds, warehouses, and plant. In exceptional cases the State participates in the cost of construction of municipal inland harbors of special importance, either by pecuniary grant or by taking a financial interest in harbors constructed by private companies. The State owns a certain number of inland harbors of commerce, such as Duisburg-Ruhort on the Rhine and Kosel on the Oder.[1] In the former case the city of Duisburg owned its own harbor and appliances, while the State constructed the new Ruhort Harbor. They were separately administered till 1905, when they were combined with the agreement that as soon as the debt for the Duisburg Harbor was paid off the ownership and administration of the whole should fall to the State. The State usually provides refuge and safety harbors for the shipping during periods of flood and ice, and for passing the winter, but in the case of the city of Frankfort, the State granted the funds for the canalization of the Main on condition that the city should construct the harbor of safety and refuge.

The costs of maintenance and administration, in so far as they are not covered by receipts from tolls, are borne by the responsible authorities—State, community, corporation, or private persons. According to the imperial constitution, the State can levy tolls for special works carried out in the interest of the shipping. These tolls must not exceed the amount necessary to provide for the costs of maintenance, working, and administration of the waterways, and to the gradual reduction of the costs of construction. They can not be levied for the purpose of revenue.

The revenue from the free rivers is very small compared to the cost of maintenance and consists chiefly of contributions, rents, etc. The tolls on the canalized rivers and canals yield a small surplus after covering the cost of maintenance.[2] The total revenue from all the Prussian waterways in 1905 left a deficit of $2,270,000 after paying the cost of maintenance. Add to this the interest on the capital at 3½ per cent, and the total annual charge to the State for waterways was $6,810,000.

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[1] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 69. [2] Ibid., p. 86.

It has been the policy of Prussia in proposals for new works within the last decade to make the construction conditional on the localities interested in guaranteeing maintenance charges and about a third of the interest and sinking fund.

About 1898 an act was passed providing for the following new works:[1]

(1) A canal from the Rhine near Laar to the Dortmund-Ems Canal in the vicinity of Heine, to cost $11,324,500. The construction of this canal was to be undertaken only on condition that before July 1, 1900, the provinces interested or other public districts, communities, etc., should bind themselves to guarantee to the Government for each fiscal year, to the amount of $127,300, any possible deficit in the cost of care and operation of this canal not covered by the navigation tolls and other such receipts collected on it; further, to pay interest at 3 per cent on one-third of the capital invested ($3,774,832) and one-half per cent toward the sinking fund if the revenue did not suffice for these purposes.

(2) Various complementary works on the Dortmund-Ems Canal between Dortmund and Bevergern, to cost $1,016,725. No conditions specified.

(3) A canal from the Dortmund-Ems Canal near Bevergern to the Elbe, in the vicinity of Heinricksburg, including several branches and the canalization of the Weser from Minden to Hameln, to cost $52,854,925.

In this case also the localities interested must guarantee the State against any deficit from the cost of care and maintenance to the amount of $405,825, also 3 per cent annually on $19,512,495, a little more than one-third of the cost, and one-half per cent toward the sinking fund in so far as these items are not covered by the receipts from tolls and other sources.

The total cost of these improvements was estimated at $65,196,175. Any surplus in one of the foregoing estimates for construction was to be applied to the others. Evidently this law was never carried out, for the program of the new law of 1905 contains, with some modifications and additions, similar provisions involving an estimated expenditure of $81,400,000.[2] One additional feature of importance is that the State of Bremen, besides undertaking to carry out some works on the Weser at its own expense, is to contribute one-third of the cost of the impounding reservoirs in the Weser Basin and of the regulation works below Hameln.

The following conditions are laid down for the new works:[3]

(1) The provinces and corporations are to guarantee the cost of administration, working, and maintenance.

(2) They are to guarantee 3 per cent interest on about one-third of the capital required, with certain alleviations during the first 10 years.

(3) They are to guarantee one-half per cent to the sinking fund from the sixteenth year onward, the State undertaking to provide the interest and sinking fund on the remaining two-thirds of the capital.

Tolls will be levied on all the cargo tonnage of the new canals. With the revenue obtained from this source, it is expected that the

[1] "Canal connecting the Rhine and the Elbe Rivers in Germany." National Waterways Commission, Doc. No. 8, p. 1, 2.
[2] Report of the Royal Commission on Canals and Waterways, Vol. VI, p. 87.
[3] Ibid., pp. 89–90.

expense of adminstration, working, and maintenance can be defrayed and 3½ per cent interest earned on the capital invested.

It is also proposed that tolls be levied on the natural waterways to cover the cost of their improvement and maintenance, in so far as it has been done by the expenditure of the State. These tolls are subject to an agreement which will have to be made with the other German States and neighboring countries.[1] It is further decided in the law of 1905 to establish a uniform State monopoly for towage on two canals and their branches.[1]

HOLLAND.

There are in Holland about 265 canals with a total length of 2,100 miles. Only about one-twentieth of the waterways belong to the State. The rest are under the control of provincial or municipal authorities, administrative corporations called "Water Schappen," and private companies. All State canals are free of tolls. They were abolished in 1900. Most of the other canals are likewise toll free.[2]

The amount expended in the improvement and maintenance of rivers (1862–1901) was approximately $57,000,000.[3]

On State canals (1878–1900) was approximately $26,000,000.[4]

AUSTRIA-HUNGARY.

Austria.—From 1848 to 1898 there was expended in Austria for river regulation approximately $100,000,000. Of this amount nearly $30,000,000 was expended in connection with the regulation of the Austrian Danube.[5] The Government was assisted in raising this enormous sum, except in a few cases, by the cooperation of the provinces, districts, and cities interested in the improvements. Apparently there was no general plan of sharing the burden, as the following examples will show:

River and portion regulated.	Date.	Total cost.	How financed.
Danube.			
1. Regulation at Vienna, Nussdorf-Fischamend, 16 miles long.	1870–1882....	$12,400,000	Province, one-third; Vienna, one-third; State, one-third.
2. From the Isper to Theben, 115 miles long.	1882 to end of 1901.	9,800,000	Yearly contributions: State, $285,000; Province, $81,000; Danube regulation fund, $122,000; total, $488,000.
3. Puchenau-Mauthausen..........	1853–1897....	642,000	Government grant, $542,000; district interested the remainder.
Elbe (Bohemia).			
4. Little Elbe, from Koniggratz to Melnik, 10 miles long.	1864–1897....	372,000	Provincial funds and districts interested.
5. Upper Elbe, from Melnik to Saxon frontier, 68 miles long.	1848–1897....	3,200,000	Government grant.
Vistula (Galicia and Silesia).			
6. Schwarzwasser-Bialka..........	1885.........	12,358	Government, 50 per cent; Province, 50 per cent.
7. From mouth of Kopidlobach to the bridge of Drahomischl.	1886–1894....	113,000	Government, 45 per cent; Province, 40 per cent; riparians, 15 per cent.
8. Illownitza - Lobnitz - Neinzendorferbach.	1886–1894....	66,000	Government, 30 per cent; Province, 40 per cent; municipalities, 10 per cent; real-estate owners, 20 per cent.

[1] Report of the Royal Commission, Vol. VI, p. 91.
[2] Ibid., p. 111.
[3] Reports from His Majesty's Representatives on Navigable Inland Waterways in Austria-Hungary, Belgium, France, Germany, and the Netherlands, p. 71.
[4] Ibid., p. 72.
[5] Ibid., p. 8.

River and portion regulated.	Date.	Total cost.	How financed.
San (Galicia).			
9. Section from Lisko to Jaroslau, 142 miles; section from Jaroslau to the mouth, 74 miles.	1871-1898....	$1,000,000	Government, one-third; Province, one third; district interested, one-third; special Government grant.
Dneister (Galicia).			
10. Section from Rozwadow to Zurawno, 51 miles long.	1893-1898....	261,000	Government, 60 per cent; Province and district, 40 per cent.
Etsch (Tyrol).			
11. Kastelbell-Galsaun, 1½ miles long.	1896-1897....	49,000	Government, 50 per cent; Province, 20 per cent; district interested, 30 per cent.
12. Meran-Sacco, 66 miles long......	1879-1896....	4,400,000	Government, $2,600,000; Province, $833,000; Southern Railway, $375,000; district interested, $609,000.
13. Sacco-Borghetto...............	1883-1888....	208,000	Government, 60 per cent; Province and districts, 40 per cent.
Mur (Styria).			
14. From Graz to the Hungarian frontier, 77 miles long.	1875-1891....	1,100,000	Government, 40 per cent; Province, 40 per cent; districts interested, 20 per cent.
Drave (Carinthia).			
15. From the Tyrolese frontier at Nikolsdorf to Volkermarkt, 110 miles long.	1884-1893....	1,000,000	Government, nine-fifteenths; Province, four-fifteenths; district, two-fifteenths.

By the law of 1901 the sum of $50,000,000 was voted for the commencement of the construction of a network of navigable canals in Austria; $15,000,000 of this amount are to be devoted to the necessary river regulations connected therewith.[1] Previous to this Austria had no canals to speak of.

Hungary.—Between 1876 and 1900, approximately $105,500,000 was spent in Hungary for the canalization and regulation of the rivers, as follows:[2]

Government expenditure..	$36,522,716
Including for administration and maintenance of works, $4,000,000.	
Government expenditure for the regulation of the Iron Gates and other cataracts of the lower Danube..	9,000,000
Expenditure for dams by the societies composed of interested persons living on the banks of the Danube, Theiss, and their tributaries......	60,000,000

In Hungary, as in Austria, except at the Iron Gates, no navigation tolls are levied, and the capital expended in developing and improving the waterways is sunk for the common good, and no direct interest on the capital invested is looked for. The receipts from the charges at the Iron Gates are intended to provide the Hungarian Government with interest and amortization on the capital expended in the regulation, and, in addition, to defray the cost of their administration and maintenance.[3]

GREAT BRITAIN.

There is no record of any governmental assistance to waterways in England, but in Scotland two canals and in Ireland four waterways were assisted by grants from the exchequer.[4] The remarkable devel-

[1] Reports from His Majesty's Representatives on Navigable Inland Waterways in Austria-Hungary, Belgium, France, Germany, and the Netherlands, p. 15.
[2] Ibid., pp. 19-21.
[3] Ibid., p. 8.
[4] Saner on the Waterways in Great Britain, p. 5.

opment of the English waterways in the eighteenth century was due entirely to private enterprise. This ceased with the coming of railroads and the gradual realization that they were a more remunerative investment.[1] No national plan for developing and unifying the waterways system of the United Kingdom has ever been undertaken, though much agitation for it has arisen in recent years.

SUMMARY.

There are in Europe, apparently, three general methods of financing the construction and improvement of waterways. At one extreme the expenditures for this purpose are borne almost entirely by the State. This is still the policy of Belgium, and was the policy of France between 1879–1903, and, to a less extent, of Germany until 1905. This method is accompanied in all these countries by a national plan of developing and unifying the waterway system. But when the State expenditures begin to assume such large proportions, as it does in France and Germany, it is found more feasible to call upon provinces and localities directly benefited by the improvement to share in the expense.

At the other extreme is the policy found in Great Britain of leaving the construction and improvement of waterways almost entirely to private enterprises, without even proper supervision or control. The result is altogether unfavorable. The existing canals and rivers, with few exceptions, are in a seriously neglected condition. More than one-third of the waterways in the United Kingdom are under the control of the railways, and consequently are not managed with a view to their development as a means of transportation. The present system has no unity. Throughout England and Wales there are scarcely two canals with a common gauge, and there are sometimes two or three gauges of locks on the same canal.[2]

Between these two extremes lies the policy of Austria-Hungary and of France and Germany in recent years of cooperation between the Government and the provinces and localities interested.

While the improvement of the waterways is still carried on in these countries according to a definite national program, the burden of providing the enormous amount of capital for carrying out the programme is shared by provinces, districts, or municipalities directly benefited according to various methods. In France, under the new law, the State can only provide one-half of the necessary capital. In Germany the State bears the larger part of the expense for new works, but the provinces and corporations are to guarantee the cost of maintenance and administration, 3 per cent interest on about one-third of the capital expended, and one-half per cent toward the sinking fund from the sixteenth year. In Austria, as the examples cited show, the State contributes anywhere from one-third to the whole of the capital required. In the aggregate the State probably contributes more than two-thirds of the total amount expended.

[1] Forbes and Ashford, "Our Waterways," p. 224. [2] Ibid., p. 238.

BRIEF STATEMENT OF THE RELATION OF WATERWAY IMPROVEMENTS TO WATER SUPPLY, IRRIGATION, AND DRAINAGE SYSTEMS, TO FLOOD AND DROUGHT PREVENTION, AND TO BANK AND OTHER RIPARIAN PROPERTY PROTECTION.

[By Col. W. H. Bixby, Corps of Engineers, U. S. Army.]

While the most important function of a river as a whole is undoubtedly its use as a free, or nearly free, route of transportation between cities, States, and countries, the river is also exceedingly useful as a means of water supply for household, municipal, factory, and farm consumption; as a means of dynamic power; as a means of drainage and sewerage; and it is also a source of danger as regards its power of destruction of riparian properties by erosion; and a source of mixed benefit and danger as regards the effects from its overflow.

As a general rule, the availability of the river for irrigation and power is greatest in the upper quarter of its length where navigation is impracticable. The river is usually most dangerous to property in the upper quarter and lower half, and its usefulness for drainage, sewerage, or refuse removal is greatest in its lower three-quarters. For direct consumption of its water by people and factories quantity and uniformity of flow and purity of water are important features; for irrigation purposes the purity usually becomes nonessential; for power alone the quantity of water, its uniform flow, and height of fall are important; while for drainage and sewerage the volume of water and swiftness of current are specially important. Droughts injure the usefulness of the river for alimentation, irrigation, drainage, and navigation purposes, and have but few, if any, redeeming qualities. Floods, though often causing great damage by bank erosion and by property destruction, are yet often of very great benefit by reason of their fertilizing deposits, which so enrich the river bottom lands that even one good crop in three years will often be profitable to the landowner.

The special conditions most favorable to each of the above functions of a river are so divergent that it is usually impossible to make any river improvement without detriment to one or more of such functions. A reasonable compromise in such matters is all that can be expected; and prominence must be given to the functions most valuable to the locality under consideration.

In Austria-Hungary, for example, the farming industries on the tributaries of the Danube are more important than the navigation interests, and special prominence is there given to drainage all the year, to irrigation in the dry season, and to flood protection in the wet season. On the lower Danube, between Belgrade and the Iron Gates, the navigation interests are preeminent, and the other interests are sacrificed. In Germany and Belgium the navigation interests seem to predominate; in Holland and England, all interests seem of fairly equal importance; while in France the navigation interests predominate on some rivers and property interests on others. In none of these countries is there any extensive and general utilization of water power on the navigable portions of rivers; the volume of water flow being too small and the river fall also too small to allow of the extensive use of the water for power purposes in the navigable parts of the river without injury to the interests of navigation.

While storage reservoirs for irrigation purposes, for city and factory use, for navigable canals, or for power on the upper nonnavigable portions of rivers are used to a moderate extent throughout Europe, artificial reservoirs at river headwaters to prevent low-water stages in the lower navigable river are not in general or extensive use. Large lakes like Lake Constance and Lake Geneva are natural reservoirs and undoubtedly act to regulate the flow of their corresponding rivers; but even in such cases it is probable that the regularity of river flow is more due to the slow gradual melting of the Swiss glaciers above these lakes than to the lakes themselves. In canalized rivers each dam forms a pool which serves as a reservoir in just the place where it can produce its best and fullest effect, and the cost of additional reservoirs at headwaters would rarely be justifiable.

Storage reservoirs at headwaters of rivers for holding back water which might otherwise produce floods are also apparently as yet of no very extensive general use. The weakest point of an ordinary storage reservoir system for flood prevention is that the most dangerous and injurious floods in a river basin are often produced by heavy rainfall in the middle areas of such basin, while the reservoirs near the headwaters of the river are too high up the river to be of use when most wanted. The disastrous 1909 summer flood in Missouri, Kansas, and Nebraska was a good example of this. Consequently in France and Austria-Hungary the protection of property from river overflow is secured usually by levees on each side of the river bank of such height and distance apart that the space between them is sufficient to hold as much water as can fall during several days of heavy rainfall in the basin above, the result of such levees being practically to form a long, narrow, temporary, and intermittent reservoir, requiring several days to fill or to empty, along the full length of the river in the place where most needed, the cost of such intermittent reservoir between levees being no more than the cost of the total of upstream reservoirs that would be necessary to produce an equally useful effect, and the bed of this intermittent reservoir between levees, i. e., the occasionally overflowed lands, being useful for valuable farming or grazing purposes in the interval between floods.

While such a reservoir between levees is useless for irrigation or alimentation purposes, yet for reducing to a minimum the property damage from floods, it appears to have proved the most satisfactory solution up to the present time; judging from what has been seen so far by the commission, as well as from the statements of various foreign and American engineers as printed in recent reports of the International Association of Navigation Congresses at European Conventions, and in the Proceedings of the American Society of Civil Engineers.

The diversion of water from rivers by pumping or by canal intakes rarely injures navigation at high-water stages, but may often do so at low-water stages by seriously lowering the water levels.

Concerning drainage and sewerage, the tendency in Europe appears to be toward allowing all reasonably clean drainage water from roofs, roads, and lands to enter freely into rivers, but toward excluding all raw sewage from rivers, so far as practicable, and encouraging the development of methods of purifying sewage prior to its deposit in

the river, or of utilizing it as a low-grade fertilizer. While the free run-off from city and farm drains and from city and country roads and cleared ground is an important element in the formation of floods in the river below, the injurious effects of the corresponding flood are probably counterbalanced by their advantages in matters of drainage; but the disadvantages and even dangers from the deposit of unpurified sewage in rivers subject to use thereafter for drinking purposes are sufficient to have already caused prohibitive legislation in many parts of the United States, and the more modern European methods and the prohibitive legislation should either be made compulsory or at least encouraged everywhere.

Throughout Europe, upon navigable waterways, the river banks below ordinary high-water level were usually found well protected against erosion by the river currents, such work being done by the General Government as a part of the river improvement. In such cases the work appeared, however, to be restricted to what was necessary to secure a proper and well-regulated river channel and bank, and to provide suitable locations for wharves, docks, and terminal facilities. In many cases, especially in France and Germany, the Federal Government, by condemnation or otherwise, acquired the riparian properties before commencing or completing the river improvements, by which process the reclaimed lands became sources of profit to the Government and helped to pay for the improvement work. This practice, so far as legal and practicable, seems worthy of being followed in the United States; and legislation in that direction should be enacted or encouraged for all locations where the local property owners do not contribute to the river improvement.

BRIEF STATEMENT OF EXISTING METHODS IN THE IMPROVEMENT OF RIVERS (INCLUDING THE CONSTRUCTION OF LOCKS AND DAMS), WITH OCCASIONAL REFERENCE TO EUROPEAN PRACTICE IN 1909.

[By Col. W. H. Bixby, Corps of Engineers, U. S. Army.]

The improvement of rivers for purposes of navigation is carried on in much the same way in all civilized countries; and the differences in methods are mainly differences of detail rather than of general principle, the extent to which such improvement is carried being more dependent upon the extent of general development of a country in population and in transportation facilities than upon the extent of technical knowledge as to river improvement, the latter being usually considerably in advance of the public demand. The recent trip of the National Waterways Commission through Europe showed that almost all the most approved methods of river improvement in Europe had been tried somewhere in the United States, and that some of these methods had even been carried to greater perfection in the United States than abroad; the marked difference between America and Europe being that the European works showed a higher degree of finish and completeness, due to a greater expenditure per mile of improved waterway, such difference being easily explained by the comparative small number of miles of rivers and other waterways in Europe in proportion to the adjacent population and to the

public wealth. This difference can easily be overcome at any time in the United States when more liberal expenditures are judged desirable.

The general course of river improvement for purposes of navigation throughout Europe as well as the United States is briefly as follows:

First. To roughly survey the river.

Second. To clear away overhanging trees from the river banks, and to clear fallen trees, snags, loose rock, and other accidental obstructions from the river bed.

Third. To give a reasonably uniform width, depth, and straightness to the natural channel of the river bed, and to mark, buoy, and light the general line of the channel where necessary, and to issue regulations for the use of the waterway with a view to making it available to as large boats as can use it without further improvement.

Fourth. To protect its banks at points of greatest wear or weakness, so as to prevent the river from spoiling its existing channels and wandering outside of desirable limits (involving both revetments and levees).

Fifth. To further improve the best channel and to give it permanence by standardizing or regularizing its bends, its cross sections, and its water slopes in open-river portions, involving careful surveys, dredging, and use of training or longitudinal dikes, contracting or spur dikes, and occasional submerged or cross dikes.

Sixth. To provide it with dams, and with locks or other boat-hoisting devices at each dam, in portions where open-river navigation becomes impracticable and "canalization" becomes finally necessary.

The last two steps are often alternative propositions.

Such route of improvement is being followed on nearly all the navigable rivers of England, France, Belgium, and Germany, about half of which have already been carried through the entire program.

In the first three of the stages of such improvement work the United States has little to learn from Europe. American survey parties are not surpassed anywhere in matter of field and office work, although such work might show to better advantage if the river engineers were authorized and encouraged to expend more money in placing the results more generally and to better advantage before the general public.

American snag boats, rock drills, excavators, dredges, etc., and their outfits and crews are in almost all respects the equal of any in the world, and in some ways are models to be followed abroad. The dredges which seem to be most commonly used on European inland rivers are of the endless chain bucket or "ladder" type, of which only a few are used in America; but it is not yet evident that they will give any decidedly better results under American laborers than the scoop, drag, dipper, clam-shell, orange-peel, suction, and other dredges in common use on our waters. In harbor and tidal river dredging European practice may be ahead of the United States in the size of some of its ladder and suction dredges, but not in their type.

On many of the European inland rivers with currents (for example, the upper Rhine) no encouragement is given boats for night travel, and such travel is made at the boat's own risk. The placing of channel marks appears to be mainly left to the engineers in charge of the river improvement works, a practice which might be advantageously followed in the United States.

The protection of banks on European rivers consists in general of, first, giving to the bank a slope dependent upon the nature of the soil and the velocity of the river current, and then covering it with a revetment of soil or gravel, small broken stone, large broken stone, paving stone, cement blocks, or sometimes continuous cement surfacing, the heavy material being sometimes underlaid by brush mattresses or other wooden supports. The best-appearing and most-used protection seemed to be that of stone riprap and stone paving, each of which type has its advocates. American practice is to use the same materials in somewhat different ways. If any change in American practice seems indicated by foreign practice, it would be merely to make the American revetments stronger and better appearing, which would add considerably to cost of first construction without perhaps diminishing the cost of subsequent maintenance correspondingly.

Where levees were seen in Europe (as especially on the Danube, in Austria and Hungary, and on the Theiss, Hungary) the general treatment of the situation appeared to be much similar to that on the lower Mississippi River, and did not indicate any special need of change in American methods. The main river levees were set back a considerable distance from the low-water river banks, by which a wide strip of land was abandoned to freshet overflow, the use of the levee being mainly to save from overflow the land in its rear, and only incidentally to turn quickly back into the river the subsiding waters. Under such circumstances the cost of the levee construction is very justly paid mainly by the owners of the protected lands, a practice which is growing in the Mississippi Valley, and should be encouraged throughout the United States wherever levees are to be built along inland rivers.

Almost all rivers which head in the mountains and which empty directly into the ocean may be considered as composed of four sections, each quite different as regards navigability. The mountain section is usually torrential in nature, and has so steep a slope and so narrow and winding a bed that it is entirely unfitted for boat navigation, though perhaps useful for floating logs. The next section is liable to have a steep slope and a small low-water discharge, so that it can be navigated as an open river only at high-water stages and can not be navigated all the year through, except after canalization. The third section is usually one of moderate slope and good low-water discharge and is usually well adapted to open-river navigation by small draft boats all the year, but must be canalized if to be used all the year by deep-draft boats. The fourth or lower section is tidal in nature and can usually be improved by dredging and regularization, so as to afford a daily open-river navigation to any boats which can cross its ocean bar. The natural open-river navigation is usually the simplest, cheapest, and most desirable, so far as it can be used. The regularized open-river channel is next in cost where practicable, and the canalization is usually the most expensive, although possible almost everywhere.

The Mississippi River from St. Paul to the mouth of the Missouri is a good example of a river which, from its moderate slope, good low-water discharge, and moderate high-water discharge, is capable of an excellent natural open-river navigation for light-draft boats;

which can be easily regularized for medium-draft boats; or which can be canalized for boats of any draft. From the mouth of the Missouri River to the Gulf, the Mississippi, from its large high-water discharge and mobile bottom, can be regularized but not easily canalized. The Ohio River, on the other hand, on account of its small low-water discharge, can not easily be regularized for even light-draft boats, although it can be canalized for medium drafts. The Great Kanawha, on account of its small low-water discharge and its steep slope, is suited only to canalization.

There are many reasons why the open-river navigation is preferable to a lock-and-dam or "canalized" navigation, namely: Economy in cost of construction, capacity for a practically unlimited and freely moving traffic, extensive frontage for landings or wharves on both sides of the river, less interference by ice in winter months, easier travel during freshets, earlier resumption of travel after unusually high freshets, deeper available draft during moderately high waters, and practicable reclamation of lands which would be flowed by dams, very much greater speed of boat travel, especially downstream, etc. But, in order to get the fullest advantage from open-river navigation, the river must be thoroughly regularized by side-contraction works, side and bottom revetments, and occasional training walls, and such works must be carefully adapted to the volume and velocity of high-water and low-water river flow, to the nature of the river banks, to the nature and general slope of the river bed, and to the dimensions of the boats using the river. Successful regularization of a river to give a good open-river navigation at all stages of water is only practicable on rivers with a gentle slope of river bed, combined with a large low-water flow compared with a freshet flow, such as in Europe the Rhone, Garonne, Durance, Loire, Lower Mense, Rhine, Weser, Elbe, Lower Oder, Vistula, Nemel, Danube, Dnieper, Volga, and the tidal portions of other rivers.

But even in these cases the low-water flow has not justified nor secured a channel depth of over 3 meters (9.8 feet) on the lower and most favored parts of the Rhine and the middle part of the Danube, nor of over 2 meters (6.6 feet) on the other rivers, and on some of these rivers only as much as 1 meter (3.3 feet), and a greater depth will probably require canalization. However, these depths, combined with the open-river free circulation, a perfected boat service, and fine terminal facilities, have, on the German rivers, led to an enormous tonnage of water traffic. North American rivers, as a general rule, average higher than European rivers in length, in depth, and in water flow. The Rhine and Danube are the only rivers of France, Belgium, or Germany which are superior in such ways to the upper Mississippi River above the mouth of the Missouri.

The Rhine, Elbe, and Danube, visited by the commission, and the Rhone, as described in printed reports, show good results obtained by regularization works where side contraction is secured by spur dikes and connecting training walls, well rivetted with stone and rising outside of the low-water channel to just above low-water level, the under-water portions being so arranged as to carefully define the desired cross section of the river bed and to protect the same from undesirable wear by the river currents. The method, as seen in Europe, is in harmony with the work also seen later on the Mississippi River, so far as carried out, and as in progress of execu-

tion. American practice in such matters seems to need no special change at present.

(A full description of river regularization, as applied to the Mississippi River between St. Louis and Cairo, based upon the best European experience and practice, is given in pp. 57–89 of the recent 1909 Board Report on Survey of Mississippi River, H. Doc. No. 50, 61st Cong., 1st sess.)

Whenever the river slope is steep or the low-water discharge is small an open river navigation, even under the best regularization, usually becomes exceedingly difficult and slow even for light-draft boats, and sometimes becomes impracticable for any boat. When the river slope is too steep and the corresponding current too great to be easily ascended by ordinary tows and an open-river navigation is still preferable to canalization, the boat service is sometimes maintained by the aid of special chains or cables, laid under water along the bottom of the river, by which the towboat pulls itself along upstream. Such chains have been extensively used on the Rhone, Seine, Yonne, Meuse, Rhine, Main, Neckar, Saale, Elbe, Danube, and some Russian rivers, but their use is lessening each year, and the chains have already been removed from portions of several of the above rivers. Higher powered stern-wheelers or side-wheelers or screw propellers seem to be gradually replacing the chain except in very swift currents or in very shoal waters. In the swift current of the Iron Gates of the Danube a wire cable of several miles length is still in use, being wound up on or unwound from a large drum on the towboat. On the other hand, on the Rhine just below Bingen, boats are to be helped up past the swift currents by the aid of a low-lift masonry lock and a short lateral canal in the river itself instead of by the aid of cable traction. All this indicates that the use of a cable or chain in such cases is diminishing rather than increasing.

Where the river slope is steep, or the low-water discharge is small, or a draft is desired greater than practicable by open-river methods, the desired river improvement is usually best obtained by the method of canalization. This method is always possible where the river banks and bed are of solid material, and becomes impracticable only in places where it is impossible to protect the dam from undermining, or where the river carries large quantities of sand, silt, or other moving material during freshets and other high waters, in which cases a raised movable or a fixed dam would be liable to silting up and to failure, and a lowered movable dam would be liable to be buried beyond practicable reach.

The canalization of rivers requires the use of dams to convert the river into a series of deep-water pools, and the use of locks or other means of raising or lowering boats from each pool to the adjacent one.

Dams for river canalization may be either fixed or movable. Fixed dams, however, appear to be at present little used for such purposes. When used, they appear to follow the usual type of construction for reservoir dams, except that they are made specially strong against damage by submergence and overflow and by swift currents during high waters and freshets.

The movable type of dam is the one most common in river-improvement work, its great advantage being that it lies flat on the river bottom during high waters and opens the entire river to free navigation as long as the high water continues.

The movable dams most used in Europe are the Poiree needle dam, the Chamoine wicket dam, the Boule gate dam, the Camere curtain dam, and the Desfontaine drum dam, or their modern modifications. In these dams the needles, wickets, gates, and curtains are supported in position either by trestles or props which rise from under-water foundations or by frames lowered from overhead bridges. With the exception of possibly the Camere curtain, which is being abandoned abroad, all the above types of dams have been built and are still in use in the United States, the needles on the lower Big Sandy River, Kentucky, the wickets on the upper Ohio and Kanawha Rivers, the gates on the Ohio at Louisville, Ky., the drums on the Osage, in Missouri, and the overhead bridges at the safety gates of Saulte St. Marie Canal, Michigan. The only points in which the foreign dams appear superior to the American are in the size and methods of maneuver of some of the Boule gate dams at places (such as the Danube canal at Vienna) where electric power is at hand and large electrodynamic cranes can be utilized for such work. Such changes will possibly be advantageous to the United States under similar circumstances. On the other hand, some of the American needles are higher and the American wickets as high as in Europe. For certain purposes of movable dam service none of the European dams seen appeared as advantageous for American use as the modern "bear-trap" double-leaf horizontal-axis dams which have for several years been in successful use on the Upper Ohio River and elsewhere in the United States, but which have been but little tested or used abroad.

The most important and vital feature of a canalized river is its lock or equivalent apparatus by which the boat is raised or lowered from one pool to another. The rapidity with which boats and their tows can pass through the locks is usually a measure of the capacity of the river for transportation purposes. As unused locks are usually a great unnecessary expense, most dams are provided at first with only a single small lock suitable to the original boat traffic, after which other locks, longer and perhaps broader and deeper, are added as the traffic develops, until finally the dam is provided with from two to four locks of total capacity from three to six times the first lock.

The earliest and most persistent type of lock and the one still most generally used is the ordinary masonry lock, composed of two masonry side walls, closed at each end by movable doors or gates, the resulting inclosure or chamber being furnished with valves and passages by which it can be filled with water from the upper pool and can discharge its water into the lower pool. A boat in the upper pool, finding the lock full and its upper gates open, can freely enter the lock chamber, after which the upper gates are closed and the lock chamber emptied of its water, the boat gradually sinking as the water falls, after which the lower gates are opened and the boat passes out of the lock into the pool below. A reverse process moves a boat from the lower into the upper pool. Each time the lock is emptied the upper pool loses a certain quantity of water, the total amount depending mainly upon the size of the lock chamber, the lift, and the load of the boat as measured by the volume of boat below water level. When the boat traffic is very great and the highest pool of a river receives but little water from its tributaries, the lack of proper water supply may limit the river traffic and require a change of lock construction to some other type using less water. A desire to economize

water, combined with a desire to hasten the passage of boats through locks, is the main reason for the substitution during recent years of inclined railways or "canal inclines" and vertical lifts for the original masonry lock. But the tendency of to-day in Europe seems to indicate a return to the masonry lock type unless the conditions of dam location and boat traffic are exceptional.

Canal inclines follow, in their construction, the general type of rail inclines for carrying passengers, wagons, and trolley cars, such as are of long and well-tested service in Pittsburgh, Cincinnati, and other American cities where side hills must be climbed. Canal lifts, in similar way, follow the general type of hydraulic lifts and electric mechanical counterpoise lifts in American hotels. In a few cases the boat is lifted from the water and hoisted dry, in cradles resting upon railroad trucks, but in most of the cases the boat is left floating in a water-filled tank, the tank itself being lifted. Small canal inclines for lifting 70-ton boats from 44 to 100 feet at one operation were used on the Morris (N. J.) Canal as far back as 1825–1831, and for lifting 115-ton boats up a 39-foot incline (total load moved being 390 tons), were used on the Georgetown (D. C.) Canal as far back as 1876.

Canal inclines appear for the moment to be gaining in the race against locks and vertical lifts. In 1900 a pair of inclined planes to lift 70-ton boats through a single height of 75 feet was put in successful operation at Foxton, on the Grand Junction Canal, England. This incline differs from its predecessors, especially in placing the water tank transversely to the line of its haul. The two tanks are connected by cables so as to balance each other, one going up as the other goes down, and the power of the operating steam engine is necessary as before to overcome only inertia and friction. During the past few years, and as the result of many competitive projects of 1904, it is reported that somewhat similar inclines are being constructed or are under contract upon the canal from the Danube to the Moldau and Elbe, at Prerau, in Moravia, in such way as to raise 600-ton boats up more than 100 feet along a 1 on 5 slope.

Small canal lifts for very small barges were used in England on the Worcester and Birmingham Canal and on the Grand Western Canal as far back as 1809 and 1834. But the use of large lifts practically dates from the construction, in 1876, of an hydraulic lift for 100-ton barges, raised 50 feet, in about three minutes for each operation, at Anderton, on the Trent and Mersey Canal, near Liverpool, England. This lift has since been followed by other much similar lifts at Fontinette, France, in 1883; La Louviere, Belgium, in 1885; Henrichenburg, near Dortmund, Germany, in 1899; and at Peterborough, near Toronto, Canada, about 1902, some of these lifting 600-ton boats up heights of over 52 feet in less than 12 minutes, the total mass in motion being over 3,000 tons. The Henrichenburg water tank rests upon and is lifted by floating inverted cylinders filled with compressed air, while the tanks of the other lifts rest upon metal plungers descending into cylinders filled with compressed water. While these lifts certainly save water and time, they are very expensive in first cost and in opreation, and their use can only be justified by exceptional local conditions.

It is evident that these lifts are not yet entirely free from objection in matter of first cost, operation, and maintenance. Attention is invited to the fact that a high masonry lock is being built alongside

of the Henrichenburg pneumatic lift and that the hydraulic apparatus of the Anderton lift has recently been replaced by mechanical counterpoises and electro-dynamic machinery. There is as yet no good reason, therefore, for changing the existing United States past practice, which is slow to give up the use of masonry locks.

The commission was fortunate in seeing the lifts at Henrichenburg and La Louviere and the incline at Foxton, but any reference to other European lifts and inclines is based upon printed reports.

Both lifts and inclines are exceedingly expensive in first cost, and are always beyond economical reach except where the canal approaches can be built with very short embankments or viaducts. In many cases it will be found cheaper to pump water even up great heights and from long distances rather than to use lifts and inclines to save water.

Where a considerable height at a single locality is to be ovrecome by masonry locks, there is usually a choice between the use of several locks of small lift or a lesser number with larger lifts. The present tendency in Europe is toward larger lifts. In many cases, two of the old locks of the Seine have been replaced by a single new lock. On the St. Denis Canal at Paris as much as 9.92 meters (32.5 feet) lift at a single masonry lock has been secured without any special inconvenience other than the loss of water. The tendency in the United States is, as in Europe, toward the use of large lifts.

In matter of lock construction details, the European locks visited by the commission, while interesting as parts of the river-improvement system, contained but few features not already in use somewhere in the United States.

Various methods were found in use to keep up the supply of water in the upper levels of canals and at high masonry locks; sometimes by side economizing basins, as at Henrichenburg (for the new building single masonry lock) and on the Bruxelles-Charleroi Canal, and at Foxton (for the rebuilding flight of masonry locks), and sometimes by direct pumpage, as at Manchester (replacing side economizing basins); the tendency being apparently toward the latter method (pumping), on the ground that it saves in lockage an amount of time which is more valuable than the cost of pumping.

The lock gates of ordinary masonry locks appear to be of various types, each having its special advantages according to local circumstances, the newest types in greatest favor for busy, wide canals being the ordinary two-leaf miter gate, moved by a thrust bar near its top, by the aid of dynamo electric machinery where practicable. At high masonry locks, however, such as on the St. Denis Canal, Paris, and on the Moldau River, the best practice seems to be to close the lower end of the lock with an arched masonry gateway and a single large "Stoney" gate, lifted by dynamo electric machinery, in much the same way as is now proposed at Panama. Europe, however, has apparently no "Stoney" gates larger than those to be seen on the power canal at St. Marys Falls, Mich., and has no ordinary miter by gates of greater height than those seen at Plaquemine, La. (55-foot width, 51-foot height, 37-foot lift), and at the Sanitary District Canal, Lockport, Ill. (22-foot width, 56.8-foot height, 34-foot lift).

As to lock valves for filling and emptying the locks, here again various types are still in use, the tendency being to the balanced cylindrical valve, operated by hand or by electricity (of type much

like that in use on the Big Sandy River, Ky.), although the balanced flat valve, with usually a vertical axis, is still the most used, and the siphon, instead of a valve, has been successfully tried on the Seine above Paris and on the new Teltow Canal near Berlin.

As regards canal aqueducts, the tendency seems to be toward the greater use of iron-reenforced concrete, such constructions being much similar to the aqueducts seen later by the commission on the Hennepin Canal near Rock Island, Ill.

In matter of guard gates for closing off sections of upper canal levels, as seen by the commission on the new Dortmund-Ems Canal, Germany, no constructions appear to have been any more successful than the automatic gates of the Hennepin Canal and the large turning-bridge safety gate of the St. Marys Falls Canal, Mich.

The general practice in France and Belgium appears to be toward keeping all movable parts of lock apparatus above water so far as possible, and to using types of construction easily operated by hand power, or at least easily handled by one or two lockmen and ordinary labor. Where electric machinery is available it is often very economical because of easy operation by ordinary lockmen and labor, its repair in such case being attended to by a special working force whose services are needed only occasionally at any one lock, and who can therefore effectively serve a long length of canal.

Appendix II.

THE UTILITY OF STORAGE RESERVOIRS FOR FLOOD PREVENTION, POWER, AND NAVIGATION.

By M. O. Leighton, Chief Hydrographer, United States Geological Survey.

This report is submitted in compliance with a request of Hon. T. E. Burton, chairman, made March 10, 1911. It relates to the utility of flood-impounding reservoirs, either constructed or proposed, in the United States.

In November, 1907, I presented to the Inland Waterways Commission a report entitled "The Relation of Water Conservation to Flood Prevention and Navigation in Ohio River." This contribution has been included in the printed report of that commission, pages 451 to 490 (S. Doc. No. 325, 60th Cong., 1st sess.). The present report is in a sense supplementary to that of 1907, covering further studies, both in the Ohio basin and elsewhere in the United States.

The report of 1907 elicited much unfavorable comment. Had it no other virtue than that of provoking the discussion that ensued it would have amply served its purpose. During the four years that have intervened since the report was submitted the partisans on both sides have had an opportunity to give more mature consideration to reservoirs, and judgment concerning them is now less likely to be warped by feelings of loyalty to preconceived notions. As might have been expected, a common ground has been located toward which the various parties have converged. Reservoir advocates, including the present writer, have been led to modify certain radical views concerning relatively unimportant details, though the accuracy of the important contentions made in the report of 1907 has repeatedly been verified. On the other hand, those who earlier opposed the creation of reservoirs have shown a very marked tendency to adopt or at least to look more favorably on certain features of the scheme.

In order that the present report may be considered in the light of full information concerning past objections, it will be well to review briefly the principal objections that were made after the publication of the report of 1907.

The reservoir scheme was generally denounced because of its alleged inefficiency. Some of its opponents argued that storage would not materially change flood conditions; others held that suitable sites were lacking in places where reservoirs would be effective, though, strangely enough, those who so held showed that they were quite unfamiliar with the topography of the Ohio River Basin. Still others cited numerous unimportant local objections, such as the flooding of land and the interruption of travel along country roads. To many

persons the submergence of large areas of comparatively worthless farm lands in the upland drainage basins of the Ohio tributaries seemed to be an insuperable objection. Notwithstanding the fact that these lands have never been very profitable as farms, certain good men drew tearful pictures of submerged homes and of banished, inconsolable families, forgetting, apparently, the compensating happiness in the rich valleys below. It ought to be apparent that the value of a few thousand acres of poor land in the highland region of any river system is not comparable with the value of a well-regulated river, whether the river be regarded as a source of power or an avenue of transportation. As a rule, the annual damage caused by floods far exceeds the value of the land whose submergence would partially or wholly prevent further floods.

Objections were also based on the supposed inefficiency of reservoirs in the double duty as preventers of floods and as aids to navigation. Many persons were inclined to contend that reservoirs would always be full when they were needed to store flood waters, or empty when water was needed to compensate low-water flow. The uses of the reservoirs were said to be antagonistic. To prevent floods the reservoirs must be emptied as soon as possible after a flood has abated, so as to be ready to receive the next flood; to serve the purposes of power and navigation the reservoirs must be full at the end of the wet season, so that the maximum use of their capacity can be made during the following dry season. Inasmuch as it is impossible to foretell the time of cessation of spring rains, no one would be able to decide when to empty the reservoir or when to close it to catch water for the dry season. To all these objections the simple answer is that such reservoir systems must be planned with a twofold capacity: First, planned to care for summer flow, providing permanent storage to be held as nearly uniform as possible; second, to provide excess capacity equivalent to maximum flood run-off; that is, sufficient to hold the largest floods. The water in this portion of the reservoir would be drawn down to the point of permanent storage as soon after a flood as possible, and the basin would be ready to catch another flood. At the same time the reservoir would store water for the low-water periods. Although this point has been repeatedly explained, these objections seem to stick in the minds of many critics.

Another objection was based on the danger of the breaking of a dam in such a system. The failure of dams with consequent loss of life has for many years been a favorite topic in song and story. It appears to give to an author just the environment and the train of circumstances necessary to produce a vivid effect and to secure an appreciative audience, but dam failures in fact are relatively few; each is traceable to some preventable error, and they will occur less frequently as engineering knowledge increases. The dam casualties of the past are not as numerous as those incident to ordinary foot traffic in the streets of a great city, especially since the day of the automobile. No one would advocate abolishing the automobile becauses its abuses result in damage to pedestrians. No one would propose giving up railroad trains because they are agents of death. The hazards are accepted because of manifold benefits conferred. So it is with the reservoir systems.

Another great objection to the reservoir scheme was the prospectively great cost. Little could be said in reply to this objection

because no surveys or estimates had been made, and little more is known at the present time. It is probable that within a few months as the result of the investigations of the flood commission of Pittsburgh cost figures will be available for reservoir systems located on the Monongahela and Allegheny. Very few estimates are available for other places. It is known, however, that such investigations of flood reservoir benefits and costs as have thus far been completed—and some of these investigations will be discussed later on—show the benefits to far outweigh the costs, especially when flood benefits are united with benefits to water power, to navigation, and, in certain parts of the country, to irrigation.

Finally, the critics of the first report seem to forget that the report was largely, if not entirely, a plea for further investigation. Certain facts were given and deductions believed to be reasonable were made. It was contended that inasmuch as a showing of possibility if not of probability was made, it would be wise to fully investigate all of the premises. The present report goes a little further, discussing certain areas outside of the Ohio Basin in which reservoirs have been constructed or the effect of proposed reservoirs has been studied, and making certain statements concerning reservoir costs and efficiencies; but it is believed that this report will have fulfilled its best purpose if it emphasizes even more strongly than did that of 1907 the duty of the Government and of the Waterways Commission to look well into this reservoir matter and take no steps toward a permanent waterways policy until sufficient information is at hand concerning the practicability, efficiency, and cost of reservoirs.

PASSAIC RIVER, N. J.

One of the most comprehensive and thorough studies of floods and flood prevention yet made in the United States was brought about as the result of a series of damaging floods on Passaic River in New Jersey. So serious were these floods that the State legislature, in special session, authorized the appointment of the Northern New Jersey Flood Commission to study the situation and to originate and present plans for corrective treatment. This commission reported in 1904 and was succeeded, under resulting new legislation, by the Passaic River Flood District Commission, having the same membership as the former one and enlarged powers and duties. The reports of the two commissions set forth all the facts necessary to support the strong recommendation that impounding reservoirs were the proper and effective means of flood prevention. As the writer was a member of both commissions and chairman of the engineering committee of each, he is familiar with all the work and the conclusions.

The drainage area of Passaic River, about 1,000 square miles in extent, occupies a large part of northern New Jersey and extends over into Rockland and Orange Counties, N. Y. Its basin is divided physiographically into the "highland area," the "central basin," and the "lower valley." The floods of the Passaic have all been caused primarily by the run-off from the highland area and the central basin, principally the former. These two portions of the basin are only 773 square miles in extent. It will subsequently be shown how great were the floods in comparison with the small size of the area.

The Passaic proper is formed by the junction of four upland streams, the Pompton, Rockaway, Whippany, and upper Passaic, draining, respectively, 380, 138, 71, and 100 square miles. All of these streams converge into the central basin, locally known as the "Great Piece Meadow"—a flat, wet piece of land over which the floods accumulate—and discharge over a fall and through a gorge at Little Falls and enter into the lower valley over the Great Falls at Paterson, N. J., some 4 miles farther down. At times of flood the waters accumulate on the central basin, discharge into the lower valley, overflow the channel, and inundate valuable properties in the large cities of Paterson, Passaic, Newark, and in many small cities and towns located on the banks between the three larger municipalities. From 1877 until 1903 there occurred in this basin 29 destructive floods.

In March, 1902, a flood of maximum discharge over 26,000 cubic feet per second caused damages to improved property and manufactured goods and raw materials of over $3,000,000. In October, 1903, a flood of maximum discharge of 37,500 cubic feet per second caused damages amounting to about $7,000,000. When it is considered that these enormous damages resulted from the flood discharges from only about 770 square miles of drainage area the seriousness of the situation will be appreciated.

The Northern New Jersey Flood Commission investigated every method for the prevention or mitigation of these floods, including channel rectification and enlargement, diversion of flood waters through conduits into other drainages, and finally, impounding reservoirs in the upland region. From the result of the studies it was clear that the last-named plan was the only practicable one for the Passaic drainage area. Detail surveys of seven reservoir sites were made, having an aggregate capacity of 33,800,000,000 cubic feet. As the total discharge of the October flood of 1903 was about 15,000,000,000 cubic feet, it is apparent that the storage capacity of the basin, if properly developed, is sufficient to more than conserve all the flood waters.

Detail studies of the floods of 1902 and 1903 showed that the control of the flow of Pompton River by the utilization of a reservoir site near its mouth would prevent all future floods from damaging the lower valley. The dam site is located at a gap between Hook and Packanack Mountains, designated as Mountain View. This site has consequently been designated the Mountain View reservoir site. It has a capacity of about 7,500,000,000 cubic feet when developed for flood control alone; of 15,000,000,000 cubic feet if the dam be raised 18 feet higher to conserve water supply for the cities of northern New Jersey. Considered for flood prevention alone, the capacity of the reservoir is about one-half the total discharge of the greatest flood ever known in the valley. Studies of the behavior of floods on the various highland tributaries showed that the Pompton and its tributaries are in all respects the most flashy in character and contribute the largest amount of water in the smallest space of time. Moreover, the flood waters from this stream discharge on the Great Piece Meadow at a rate and in a direction which rapidly piles the water up there and adds far greater intensity to the floods than the equivalent of the drainage area in proportion to that of the remainder of the Passaic Basin. It was conclusively shown by the studies

of the commission that with the Mountain View reservoir constructed the flood in the lower valley in October, 1903, would not have reached a greater discharge than 14,000 second-feet, or less than one-third the discharge that actually took place. Further studies of the commission show that the channel along the lower valley is capable of carrying off a discharge of 14,000 second-feet without doing any material damage to the property along the river. The total cost of this reservoir, including all structures, damages, railroad relocations, etc., was estimated at $3,849,000, or a little more than one-half of the cost of the damage caused by the one flood of 1903.

The Mountain View Reservior was never built. The State administration was changed shortly after the presentation of detailed plans, and this fact, together with certain unworthy antagonisms arising between the cities of Paterson and Newark, made it impossible to secure an agreement concerning the matter. During the years since 1903 the Passaic has been free from disastrous floods, and this is the main reason why nothing has been accomplished. It will probably be necessary for the communities in the lower valley to sustain another enormous flood loss before the matter will again be seriously considered.

NEW YORK STATE.

Flood-prevention studies have been made by various State and local commissions in New York. All the work has finally been brought together, reviewed, and extended by the New York State Water Supply Commission. Brief reference will here be made to two of these studies—one on the Genesee and the other on the Hudson.

GENESEE RIVER.

The lower basin of the Genesee, especially that part lying between Mount Morris and Rochester, N. Y., suffers frequently from severe floods. They inflict great damage on improved property in the city of Rochester, menace the barge canal at that point, and cause great road, crop, and improvement losses in the rural districts. Various commissions, both local and State, have studied the subject with care and the final plan of the New York State Water Supply Commission constitutes the results of what is probably the most mature local study that has ever been made.

The plan adopted is designed to give flood protection and increase the water power by compensating the low-water flow from storage. The benefits of such a development are described by the New York State Water Supply Commission substantially as follows:

About 25,000 acres of rich farming land in the valley of the Genesee lying between the village of Mount Morris and the city of Rochester would be protected against devastating floods which now occur almost annually, destroying crops, undermining bridges, and washing out highways, and thereby causing very heavy pecuniary losses to the counties, towns, and individuals. The property and roadbed of five railroads would be rendered more safe and their traffic uninterrupted by the high water.

The water-power interests at Rochester would be guaranteed a minimum regular flow during the dry period of the year of from three to five times that which they now enjoy. It would mean a saving of large sums of money annually for coal and other operating expenses of auxiliary steam plants.

The capacity of the water-power plants at Mount Morris could be multiplied fivefold if modern hydraulic installation were made and advantage taken of the increased flow in the river.

Hydraulic power to the extent of 30,000 continuous seven-day horsepower could be developed at the dam site for transmission electrically to Rochester or other markets as the demand for power should develop.

The new State canal and the harbor at Rochester would be protected against dangerous fluctuations in the water level, and the consequent interruption to the traffic and a saving in cost would be effected by a reduction in the required width and depth of the harbor for the passage of flood waters.

The river bed in and below the city of Rochester, into which the city pours its sewage and refuse, would be rendered more sanitary than at present, and instead of being a sluggish pool and a nuisance for six months of the year it would become a flowing stream with sufficient current to dilute and carry the offensive matter beyond where it could do harm.

The plans involve the construction of a masonry dam at Portage, N. Y., 152 feet high from foundation to coping. The reservoir formed would have an area of water surface when filled of 13½ square miles. The bottom of the reservoir at the lowest outlets in the dam would be 1,095 feet above sea level. Above this the water stored in the reservoir for the next 45 feet, or up to elevation 1,140 feet above sea level, would be held in practically permanent storage and used to compensate low-water conditions in extraordinarily dry seasons, which come infrequently. The next 55 feet of storage, or up to elevation 1,195 feet above sea level, would be used both for new power development and to increase the capacity of the powers already established along the river. The amount of water stored between these two levels would be 11,250,000,000 cubic feet. The next 15 feet of reservoir capacity, up to elevation 1,210 feet above sea level, would be used for flood catchment. The capacity between these elevations is 6,750,000,000 cubic feet, sufficient to temporarily store all except the most extreme and unusual floods. For the latter an additional 5 feet of storage is provided above the 1,210-foot elevation. The floods would begin to spill from the reservoir through automatic flood-regulation ports after it surmounted an elevation of 1,195 feet and would pass over the spillway at elevation 1,210 feet. In the operation of this reservoir the permanent storage for water-power development would be limited to the 11,250,000,000 cubic feet at elevation of 1,195 feet. Whenever the space above this elevation was filled by floods, the level would be drawn down again to the elevation 1,195 as fast as the condition of the river channel below would permit, and the reservoir made ready to receive another flood.

The present flow of Genesee River at the Portage Dam site ranges from 80 cubic feet per second at low-water stage to 42,000 cubic feet per second in time of great floods.

The commission has made surveys and estimates and has prepared charts which show that the crest of all except the very greatest floods

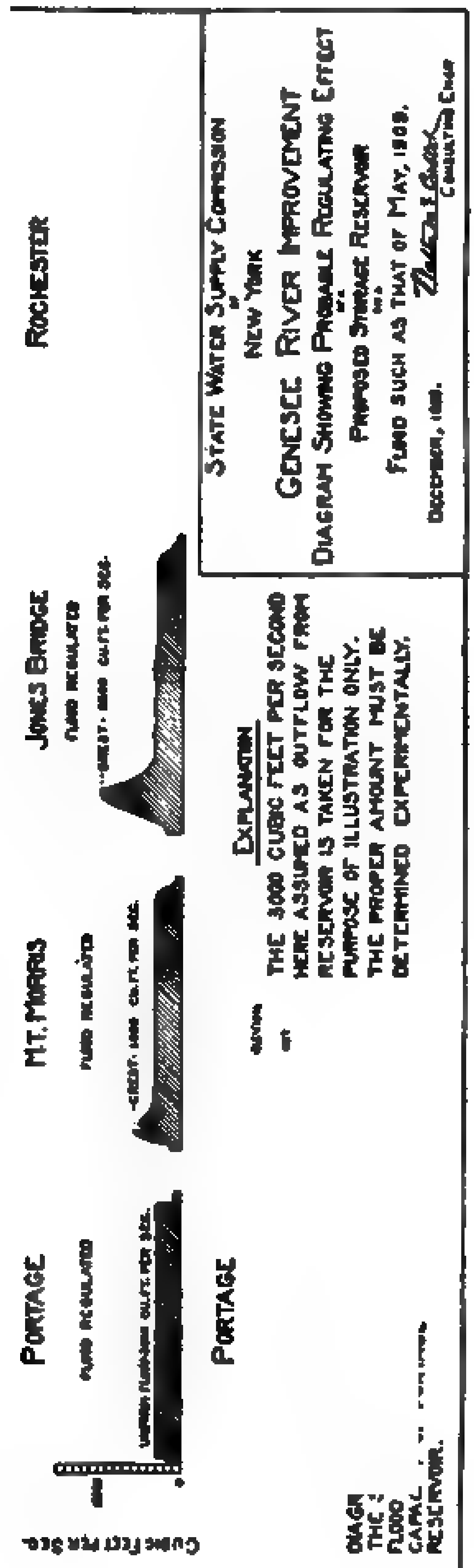
on the Genesee can be cared for by the estimated storage capacity. While the floodwaters are storing back of the dam, above the 1,195-foot elevation, the spillway ports would be discharging at the maximum 12,000 cubic feet per second; and it has been estimated that a discharge at Rochester of 33,000 cubic feet per second could be permitted without damage. The discharge of 12,000 cubic feet per second from the reservoir would therefore not allow any overflowing of the valley between Mount Morris and Rochester.

In addition to the benefits from flood regulation the foregoing plans would in the ordinary year increase the available water power at Rochester from 9,800 horsepower to 25,370 horsepower and also provide for a 32,000-horsepower plant below the site of the dam at Portage. The river regulation would increase the minimum flow at Rochester from about 200 cubic feet per second in the driest year to 1,180 cubic feet per second. The increase of power at Rochester for the driest year would be 5.9 times the present minimum. Under such a plan the Genesee Basin would become one of the most important centers of water power in the State of New York.

The water-storage commission has made and presented in its annual report for the year 1910 a most interesting study of the effects such a dam as that above described would have on a great flood similar to that which occurred in May, 1909. This flood was the highest in point of volume and flood effect that has occurred during recent years, and it submerged in all about 25,000 acres of land. The peak of the flood was equivalent to a flow of 25,000 cubic feet per second. A study of the situation indicated that a discharge of about 12,000 cubic feet per second at Mount Morris could have been confined to the lower channel without causing any damage to the lower country. When the flow is greater than 12,000 cubic feet per second at Mount Morris, there is usually at the same time a large volume of water discharged into the Genesee by the Canaseraga, its principal tributary, which joins the river below Mount Morris. The combined flow is therefore too great to be carried by the channel when that from above Mount Morris is greater than 12,000 cubic feet per second. The result of the flood of May, 1909, and that which would have taken place had the proposed Portage reservoir been constructed is diagrammatically shown on sheet 1, which is taken from the report of the New York State Water Supply Commission for 1910. The enormous benefits are obvious from an examination of this diagram.

The water-supply commission presents in its last annual report the following estimate of cost of and revenue from the Portage reservoir and power scheme:

Estimated cost of Portage reservoir with dam at the most practicable site and an intake, pressure tunnel, and power house for power development, but without machinery		$6,800,000
Annual fixed charges on the above, including interest and sinking fund		300,000
Estimated gross annual revenue:		
From power development at the reservoir	$300,000	
From power improvement at Mount Morris and Rochester	115,000	
From river improvement in the Genesee Valley and in the city of Rochester	35,000	
		450,000
Net revenue		150,000


STATE WATER SUPPLY COMMISSION
OF
NEW YORK
GENESEE RIVER IMPROVEMENT
DIAGRAM SHOWING PROBABLE REGULATING EFFECT
OF
PROPOSED STORAGE RESERVOIR
FLOOD SUCH AS THAT OF MAY, 1909.
DECEMBER, 1909.
ROCHESTER
JONES BRIDGE
FLOOD REGULATED
M.T. MORRIS
FLOOD REGULATED
PORTAGE
FLOOD REGULATED
PORTAGE
Cubic Feet per Sec.
EXPLANATION
THE 3000 CUBIC FEET PER SECOND
HERE ASSUMED AS OUTFLOW FROM
RESERVOIR IS TAKEN FOR THE
PURPOSE OF ILLUSTRATION ONLY.
THE PROPER AMOUNT MUST BE
DETERMINED EXPERIMENTALLY.
RESERVOIR.

HUDSON RIVER.

The State Water Supply Commission of New York has conducted surveys in the basin of Hudson River above the mouth of Mohawk River for the purpose of determining the feasibility of developing reservoirs and the effect of such reservoirs on the flow of the stream and on the water powers already established, as well as on the water-power privileges yet undeveloped. The physical conditions on this drainage basin are extremely favorable. At Mechanicsville, N. Y., the total discharge has been known to range from 700 second-feet to 70,000 second-feet, and the average flow is about 8,120 second-feet. Investigations so far made show that 61,000,000,000 cubic feet of storage is the maximum practicable amount that may be developed in the basin. Twenty-nine billion cubic feet can be stored in the proposed Conklingville reservoir on the Sacandaga and 16,000,000,000 cubic feet more can be stored over the Schroon Lake system. The effect on the Hudson is illustrated by accompanying sheet No. 2.

One of the interesting and important features of the effect of this reservoir system is that on navigation in the Hudson. This effect has been studied by the State engineer's office and by the water-storage commission. So important is this feature that the following statement is abstracted from the report of said commission for 1909.

There is sufficient depth of water in the Hudson between New York City and New Baltimore for seagoing vessels. Above New Baltimore a number of low, flat islands divide the river into two or more shallow channels, in which there is a tendency to the formation of troublesome bars. From New Baltimore to Troy, a distance of 20 miles, much dredging has been necessary to maintain an open channel. This dredging was carried on first under State appropriations, supplemented by local contributions. Between 1831 and 1892 the work was done under joint appropriations from the State and National Government. In 1892 a navigable channel, substantially 11 feet deep from New Baltimore to Albany and 9 feet deep at mean low water from Albany to Troy, had been secured. The Federal Government has been engaged in improving the channel since 1898, and the projects provide for a channel 400 feet wide and 12 feet deep from Coxsackie to the foot of Broadway, Troy, and thence to the State dam, for a channel 300 feet wide and 12 feet deep. The estimated cost for this work authorized by Congress in 1898 was $4,344,000, and the total sum expended between 1897 and 1908 for the improvement and maintenance of this portion of the river has been substantially $5,250,000. In 1895 Mr. George W. Rafter, an engineer of wide experience and of good repute, reported to the State engineer of New York that the erection of impounding reservoirs in the upper Hudson of capacity sufficient to provide for a flow of not less than 4,500 cubic feet per second in the Hudson at Mechanicsville will insure an increased depth of water at Albany of 1½ feet. This report was made after a careful analytical study of the daily tide records kept by the United States Engineer Department and taking into consideration governing conditions, such as the direction of the wind, the phases of the moon, and the daily volume of flow in the river.

The State water-supply commission has not made any independent investigation of the subject, but a review of Mr. Rafter's work, based

on his observation, has confirmed his deductions. The commission believes that a broader study of longer term data is necessary, but states that, inasmuch as Mr. Rafter based his judgment on a controlled flow of 4,500 cubic feet per second at Mechanicsville and inasmuch as the establishment of the Sacandaga Reservoir will afford a controlled flow of 6,500 second-feet, or 2,000 second-feet more than

that assumed by Mr. Rafter, it appears reasonable to assume that the increased depth at Albany would certainly not be less than the 1½ feet estimated by Mr. Rafter. With respect to this point the commission mentioned that a plan is on foot to secure a 22-foot channel from Hudson to Troy, the cost of which has been estimated at nearly $20,000,000, of which about $7,000,000 would be applied to the river below Albany. On this basis it is evident that the reservoir improvement will proportionately reduce the amount necessary to spend for excavation, in order to achieve the 22-foot channel. The 1½-foot depth acquired by reservoir construction would be 15 per cent of the extra depth required for the channel improvement and would probably result in a saving of not less than 15 per cent of the cost of the channel improvement, or about $3,000,000. A liberal estimated cost of the Sacandaga Reservoir is given by the water-supply commission as $4,650,000. Thus it appears that 65 per cent of this cost would be represented by improvements in the navigable portion of the river below Troy, and when it is noted that the reservoir construction would add to the water resources of the immediate region 85,500 horsepower, the benefits of the reservoir project require no further demonstration.

SACRAMENTO BASIN.

Sacramento River is one of the most troublesome flood streams in the United States. Its basin occupies the northern part of California, lying between the Sierra Nevada on the east and the Coast Range on the west. It extends to Mount Shasta, in the extreme northern part of the State, and southward to San Pablo Bay. The tributaries running from the mountain ranges on each side discharge large amounts of water into the main stream during times of excessive precipitation. These waters can not be carried in the normal channel of the river. A large part of the bottom of the valley is made up of great low tracts, called the Colusa, the Yolo, the Yuba, the Sutter, the American, and Sacramento Basins, and become at times of flood a part of the river itself. It has been estimated that 1,250 square miles of the Sacramento Valley are overflowed periodically and 1,700 square miles are overflowed during large floods. The basins comprise some of the best agricultural land of the State and constitute the great body designated as "swamp and overflow land" given to the State of California by the Federal Government under the swamp-land act of 1850.

The reclamation of this land for agriculture constitutes one of the most beneficial works of development in the State of California. From the time the land was given to the State, in 1850, down to the present, numerous plans have been executed for the shutting off of the flood waters of the Sacramento. Levees have been constructed, drainage works excavated, and much of the land is now productive. The grave feature of this reclamation work is that as the great basins have been progressively shut out of the flood plain of the Sacramento, the water which would otherwise flow over them has been more and more closely confined to the established channel of the river, and the flood crests have therefore been raised higher, or the water has inundated other and higher land to a greater extent than would have

occurred under the original conditions. This condition has become so acute that the river is confined to its channel only with difficulty and breaks through the levees at every great flood.

Sacramento River is navigable from its mouth a distance of 262 miles, up to Red Bluff, Cal. The necessity for preserving and promoting navigation places certain features of control of this river within the province of the Federal Government. It is needless to review the work of the past and the participation of the United States therein. Suffice it to say that the problem has come down to the present time without satisfactory solution, and it now constitutes one of the most difficult river matters before the State or the Federal Government. The commissioner of public works of California estimated that about $17,000,000 have been spent by private parties, reclamation districts, and the State itself in the reclamation of swamp and overflow lands and the control of the stream. In addition to this, the Federal Government has spent about $1,200,000 on the Sacramento, San Joaquin, and Feather Rivers for maintenance of navigation.

To indicate in some degree the nature of the measures recommended for the solution of this problem, the plan proposed in 1904 will be briefly described.

Immediately after the flood of February and March, 1904, a call was issued for a State river convention for the purpose of harmonizing all the interests concerned in the reclamation of the Sacramento Valley and to secure concerted action in devising plans for relief from future flood damage. A commission of four engineers was employed to make a study of the overflow problem and to prepare plans and estimates of the cost of the works necessary to restrain the Sacramento and permanently reclaim the swamp and overflow lands.

The plans presented by this commission are given in the annual report of the commissioner of public works of California for 1905. Briefly, they provide for channel rectification and enlargement by natural and mechanical agencies so as to confine and pass safely the whole flood volume of the tributaries through the main river channel. Until such time as rectification and enlargement are complete temporary by-pass channels were to be provided with escapement weirs leading to them to relieve the levees of pressure. The principle of concentration in a large channel was opposed to the principle of division into three channels, as recommended in the plans submitted in 1894. The plans provide in detail, first, to confine the flood waters to the channel of the various side streams by means of levees, so as to prevent destructive inundation of the fertile valleys; second, to correct the alignment of the river by cut-offs whenever necessary and to increase its channel capacity by mechanical means (dredging) whenever current action fails to accomplish this purpose; third, to collect the hill drainage which now loses itself in the basins and intercepting canals and convey it into the river at selected points; fourth, to provide escape ways over the levees for surplus flood water during the period of channel development and to provide for the disposal of this water in connection with the hill drainage; fifth, to provide for the relief of the basins from accumulations of rain and seepage water by means of pumps wherever gravity drainage is not practicable. The estimated cost of the proposed works was $23,776,000.

Assuming that 1,000,000 acres would be reclaimed by the works proposed in the previous paragraph, the cost would be about $23.78 per acre; but two of the items in the cost, namely, channel development and land damages must be largely increased, as will hereinafter be shown, to provide against floods of the magnitude of those of 1907 and 1909. The maximum rate of flow assumed by the board of engineers in computing the necessary area of waterway was only about 40 per cent of that which took place in March, 1907.

The enormous extent of the foregoing plans will be appreciated. It involves the permanent setting apart of a large area of valuable agricultural lands between the levees for overflow channels. The width of a channel sufficient to carry the flow is so great that the question at once arises whether there is any other possible solution or partial solution of the problem. Very high floods in the Sacramento last only a few days. If the rate of flow on these days could be reduced by, say, 20 per cent, the necessary channel width might be proportionately reduced. The storage of a comparatively small proportion of the total flood volume will permit a material reduction in channel width throughout the whole length of the valley. The question of reservoir control therefore becomes important. At the outset it should be recognized that any acceptable scheme for improving flood conditions in this basin must include within its purview the interests of navigation, irrigation, and water-power development. The use of a reservoir for flood storage and industrial purposes conflicts to some extent, as has been said on a previous page.

Complete studies have not been made, and no final statements of the practicability of combining the several uses of reservoirs in the valley can be given. The practicability of reducing floods will, however, be considered, and if it proves promising there will be suggested the desirability of making a more detailed investigation.

Many available reservoir sites in the Sacramento Basin have been surveyed by the United States Reclamation Service in connection with its Sacramento Valley irrigation project or by private companies in search of impounding reservoirs for irrigation or power purposes. These surveys indicate that the drainage areas tributary to the reservoirs comprise 48 per cent of the total area of the Sacramento Basin, and that the sites are so situated as to have a capacity sufficient to hold back the flow equivalent to 21 per cent of the discharge from the basin during the greatest storm.

The following table presents a summary of the preliminary estimate of capacity and cost of reservoirs surveyed in the Sacramento Basin:

Summary of preliminary estimate of cost and capacity of reservoirs surveyed in Sacramento Basin.

Improvement description.	Drainage area.	Capacity of reservoir basin as surveyed.	Probable amount available annually from basin.	Estimated cost of installation, 1900–1905.	
				Total cost.	Cost per acre-foot available.
PUTA CREEK.					
Guenoc Reservoir:	*Sq. miles.*	*Acre feet.*	*Acre-feet.*		
Loose rock-fill dam, with wasteway	91	188,000	279,000	$358,190	$4.47
Concrete gravity dam, with wasteway	91	188,000	279,000	557,025	6.96
Monticello Reservoir: Concrete rubble dam with spillways	603	133,000	601,000	1,219,075	12.31
CACHE CREEK.					
Clear Lake:					
Outlet channel, 8,000 second-feet capacity	486	100,000	407,000	539,750	5.40
Outlet channel, 12,000 second-feet capacity	486	100,000	407,000	681,354	6.81
Little Indian Valley Reservoir: Concrete rubble overflow dam	123	76,500	([2])	517,950	10.36
STONY CREEK.					
Briscoe Reservoir: Concrete gravity dam, with wasteway	58	14,400	([2])	251,024	17.45
Stony Ford	110	40,000	([2])	....	....
East Park Reservoir: Concrete gravity dam with wasteway	102	36,800	75,000	237,543	4.48
Mill site: Loose rock-fill dam with wasteway	323	34,700	579,000	670,010	15.32
PITT RIVER.					
Jess Valley Reservoir: Loose rock-fill dam with wasteway	91	244,600	55,000	196,500	5.61
West Valley Reservoir: Loose rock-fill dam with wasteway	142	94,600	25,000	175,000	7.00
Warm Spring Valley Reservoir: Loose rock-fill dam with wasteway	1,500	559,000	423,000	670,300	2.00
Round Valley Reservoir: Loose rock-fill dam with wasteway	265	185,000	107,000	389,000	9.16
Big Valley Reservoir: Concrete overflow dam	2,950	3,196,000	735,000	2,640,150	2.64
SACRAMENTO RIVER.					
Iron Canyon Reservoir: Rubble concrete with wasteway	6,350	226,900	11,860,000	1,855,000	8.20
FEATHER RIVER BASIN.					
North Fork.					
Concow Reservoir	....	10,000	([1])	....	....
Big Meadows Reservoir	506	780,000	975,000	....	....
Butte Valley Reservoir	....	107,000	([2])	....	....
Indian Valley Reservoir: Concrete rubble overflow dam	733	668,000	605,000	1,760,000	4.40
American Valley Reservoir	172	86,100	([2])	....	....
Spanish Ranch Reservoir	....	8,500	([1])	....	....
Buck Valley Reservoir	....	37,843	([1])	....	....
Middle Fork.					
Grizzly Valley Reservoir: Concrete rubble or rubble masonry overflow dam	44	61,800	([1])	174,843	5.14
Mohawk Valley Reservoir	682	12,600	([2])	....	....
YUBA RIVER.					
Oregon House Valley Reservoir	....	90,823	90,800	....	....
AMERICAN RIVER.					
Greenwood Reservoir	....	65,952	65,900	....	....

[1] Supply probably smaller than surveyed capacity.
[2] Supply probably larger than surveyed capacity.

A somewhat detailed study has been made by E. C. Murphy, hydraulic engineer, U. S. Geological Survey, of the effect such reservoirs would have had on the flood of March 18–21, 1907. During those four days the Sacramento basin experienced the most destructive flood financially that has ever occurred in California. The lower Sacramento, the Feather, and the American especially reached the highest stages ever recorded. The rate of flow into the main valley from the upland tributary streams largely exceeded the rate used by the commission of 1904 as a basis for computing the proper width of channel to safely carry the flood waters. A channel sufficient to carry the flood of 1907 would be 1,500 to 2,500 feet wide. The effective capacity of the reservoir in comparison with the aggregate flood volume of the river from March 18–21, 1907, is shown in the following table:

Reservoir storage data, Mar. 18 to 21, 1907.

Reservoirs.	Drainage area.	Aggregate flood volume in 1,000 acre-feet.					Reservoir capacity (1,000 acre-feet).
		Mar. 18.	Mar. 19.	Mar. 20.	Mar. 21.	Total.	
	Sq. miles.						
Sacramento River Basin, Iron Canyon	6,350	184.4	272.7	338.4	220.2	1,015.7	226.9
Pitt River Basin, Big Valley	2,950	49.6	54.5	49.6	41.2	194.9	3,196.0
Feather River Basin:							
Big Meadow	506	14.9	19.5	17.3	13.3	65.0	500.0
Indian Valley	740	18.8	22.6	20.0	15.6	77.0	688.0
Grizzly Valley	44	2.8	3.4	3.0	2.3	11.5	61.8
Mohawk Valley [1]	682	71.8	89.9	57.0	43.9	262.6	12.6
American Valley [1]	172	18.1	22.7	14.4	11.1	66.3	86.1
Bucks Valley and Spanish Ranch [1]	29	3.2	4.0	2.6	2.0	11.8	46.3
Below reservoirs and above gauging stations [1]	1,474	155.4	193.0	123.3	94.9	566.6	....
Stony Creek Basin:							
East Park	102	6.4	4.5	3.1	1.9	15.9	45.0
Stony Ford [1]	110	10.2	7.8	5.2	2.6	21.4	40.0
Briscoe [1]	58	5.3	4.1	2.7	1.3	11.1	14.4
Mill site [1]	330	30.6	23.2	15.7	7.7	77.2	43.7
Cache Creek Basin:							
Clear Lake	486	3.5	4.1	4.4	4.6	16.6	100.0
Little Indian [1]	123	4.0	5.8	3.5	1.9	15.2	76.5
Below reservoir and above gauging stations [1]	621	19.6	28.1	17.2	9.2	74.1	....
Puta Creek Basin:							
Guenoc	91	22.0	27.7	9.7	5.3	64.7	188.0
Monticello [1]	660	16.6	20.9	7.3	4.0	48.8	130.0
Below reservoirs and above gauging stations [1]	54	1.4	1.7	.6	.3	4.0	....

[1] The run-off per square mile is assumed to be constant over the basin above the gauging station.

This estimate considers only the best reservoir sites and omits some of those listed in the previous table. For example, in the Pitt River Basin only the Big Valley Reservoir is considered, because it lies at a lower elevation than all the others and its capacity is sufficient to hold all the run-off from the Pitt River Basin.

It will be noted that some of these reservoirs would have been only partly filled by the flow of March 18 to 21; others would have stored but a small proportion of the run-off that passed them. The table shows that the four reservoirs in Stony Creek Basin would have stored the run-off from 457 square miles, or from 76 per cent of the area above the gauging station, and would have reduced the maximum daily flow from 26,500 to 7,000 cubic feet per second. The two reservoirs in Cache Creek Basin would have stored the flow from 609 square miles of basin, or 50 per cent of the area above the gaug-- station, and would have reduced the daily maximum flow

19,200 to 14,300 cubic feet per second. The two reservoirs in Puta Creek Basin would have stored the flow from 751 square miles, or 92 per cent of the area above the gauging station, and would have reduced the maximum daily flow from 25,400 to 800 cubic feet per second. The seven reservoirs in Feather River Basin would have stored the flow from about 1,515 square miles, or 42 per cent of th area above the gauging station at Oroville, leaving 2,125 square miles uncontrolled. Of the uncontrolled area, 651 square miles are above the Mohawk Valley Reservoir and 1,474 square miles are below the reservoirs and above the gauging station. The storage proposed on this river would have reduced the daily flow at Oroville as follows:

From 144,000 to 114,000 cubic feet per second on March 18.
From 179,000 to 143,000 cubic feet per second on March 19.
From 120,000 to 90,000 cubic feet per second on March 20.
From 92,500 to 69,500 cubic feet per second on March 21.

Big Valley Reservoir, on Pitt River, would have stored the entire flow at that place and would have reduced the daily flow of the Sacramento at Red Bluff about 25,000 cubic feet per second. The storage at Iron Canyon, on the upper Sacramento, together with that of the Big Valley Reservoir, would have reduced the greatest daily flow of the Sacramento River at Red Bluff from 196,000 to 143,000 cubic feet per second.

The combined effect on the flow of the Sacramento of operating all these reservoirs would have been to reduce the maximum daily flow at Red Bluff about 53,000 cubic feet per second. Just below the mouth of Stony Creek the maximum daily flow would have been reduced 63,000 cubic feet per second, and just below the mouth of Feather River the reduction would have been 92,000 cubic feet per second. It should be remembered in this connection that this 92,000 cubic feet per second, though only a comparatively small proportion of the flood flow, would have represented crest flow; that is, that portion of the flow at the height of the flood which does the greatest amount of damage.

During the flood of March, 1907, the flow from about 83 per cent of the mountains and foothill portion of the Sacramento Basin was measured at eight of the Geological Survey gauging stations. The mean daily stage and discharge at each of these stations for the 11 days March 16 to 26 are given in the following table:

Discharge of streams in Sacramento Basin during flood of March, 1907.

Date.	Sacramento River at Red Bluff.		Pitt River at Bieber.		McCloud River near Gregory.		Feather River at Oroville.		Yuba River near Smartsville.	
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
Mar. 16	6.6	23,200	6.5	2,770	2.8	2,460	[1] 7.5	8,540	14.3	6,600
17	10.0	39,000	12.8	17,400	4.0	4,210	[1] 14.7	34,800	24.0	56,000
18	21.4	118,000	15.5	25,000	9.4	19,400	[1] 32.4	144,000	27.9	85,000
19	26.05	165,000	16.4	27,500	12.0	30,000	[1] 38.0	179,000	29.2	100,000
20	[2] 28.7	196,000	15.5	25,000	10.65	24,300	28.65	120,000	24.0	60.000
21	22.85	132,000	14.0	20,800	7.5	13,000	24.3	92,500	18.5	27,000
22	18.4	92,800	11.5	13,800	5.9	8,440	19.95	65,200	15.9	14,000
23	21.65	120,000	9.7	8,810	5.5	7,440	18.75	58,000	16.4	16,500
24	16.8	80,800	8.5	6,110	4.9	6,060	15.65	40,100	15.0	11,000
25	14.3	63,600	7.4	4,160	4.55	5,300	14.55	34,000	14.5	9,900
26	13.3	57,100	7.3	4,000	3.95	4,120	13.85	30,200	14.1	8,900

[1] Estimated from readings of Weather Bureau gauge at Oroville. [2] Maximum stage, 29.4 feet.

Discharge of streams in Sacramento Basin during flood of March, 1907—Continued.

Date.	Bear River near Sheridan.		American River near Fairoaks.		Indian River near Crescent Mills.		Stony Creek near Fruito.		Cache Creek near Yolo.		Puta Creek near Winters.	
	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
1907.	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
Mar. 16	4.9	760	6.1	7,030	4.45	905	......	......	......	......	......	......
17	13.95	14,400	13.4	34,600	7.1	2,570	9.45	6,080	6.8	3,010	15.3	9,840
18	12.75	11,400	20.6	70,000	17.0	9,500	14.25	26,500	19.45	13,700	21.6	20,200
19	17.8	25,800	27.6	105,000	[1] 19.7	11,400	13.15	20,000	[2] 25.9	19,200	23.65	25,400
20	18.6	13,500	23.8	86,000	17.9	10,100	11.8	13,500	18.2	12,700	16.15	8,900
21	9.6	5,620	21.0	72,500	14.7	7,890	9.8	6,820	12.65	7,940	12.35	4,850
22	8.8	4,550	18.4	59,000	10.95	5,260	7.75	3,210	12.0	7,390	11.9	4,600
23	13.2	12,500	13.5	34,700	9.0	3,900	11.55	12,400	20.85	14,900	[3] 26.6	30,000
24	9.7	5,750	13.25	33,500	7.8	3,060	8.7	4,690	19.3	13,600	15.6	9,450
25	9.4	5,350	12.3	29,100	7.7	2,990	8.15	3,800	16.15	10,900	14.75	9,000
26	8.1	3,740	11.5	25,500	7.5	2,850	7.75	3,210	12.55	7,860	11.4	5,200

[1] Maximum, 20.2 feet. [2] Maximum, 26.4 feet. [3] Maximum, 28.15 feet.

It is impossible to trace accurately the progress of the maximum flood flow down through the Sacramento Valley; that is, the portion lying between Red Bluff and the mouth. The channel capacity is exceedingly variable from point to point. In some places levees confine the water in a definite channel, and in others the floods spread over the country as soon as they have risen above the low natural bank. So it is that at no point is there a stage which would correspond to any particular regimen of flow and by which the flood could be unmistakably traced. Add to this the fact that levees frequently break during great floods, letting water that would otherwise be within definite channels spread out over wide areas, thereby complicating still further the relation between volume and river stage, and the futility of such an attempt is apparent.

It appears evident that no levee plan alone is going to be effectual in solving the great problem of the control of the Sacramento. The inadequacy of the plan of 1904 has been noted. A readjustment to cover this new flood dimension would involve the permanent condemnation of an enormous amount of valuable land.

The logical way to provide for this matter is to actually decrease the amount of water. The reservoir capacity in the drainage area is apparently not sufficient to prevent floods, but it is sufficient to markedly reduce their severity. The cost of such reservoirs, it appears, will be amply returned by benefits to water power, irrigation, and navigation, not to mention the benefits arising from partial relief from flood menace.

RESERVOIRS IN UPPER MISSISSIPPI BASIN.

The construction of reservoirs in aid of navigation, and incidentally for flood mitigation and the development of water power, is not new in the United States. Five reservoirs have already been built in Minnesota and have been operated successfully. They compose, however, only a part of the original project, and, in view of the satisfactory results obtained, which have been repeatedly affirmed by boards of United States engineers and engineer officers of the corps, the failure of the Government to complete the original plans and to

extend them to cover many well-known sites has caused no little comment.

A favorable report on the operation of these reservoirs by a board of engineer officers of the Army appears in the report of the Chief of Engineers for 1906. An able discussion of the whole subject by Charles W. Durham, principal assistant engineer, United States engineer office, at Rock Island, Ill., was published in the Engineering News of January 20, 1910. Mr. Durham has been identified with improvement work on the upper Mississippi for 39 years. His record as an engineer and as a careful, observant man is unquestioned, and his statements are entitled to the highest consideration.

Briefly stated, Mr. Durham's final conclusion is that the construction of the proposed reservoir system would secure, in connection with the 6-foot channel project, a navigable depth of at least 12 feet at the extreme low-water period from St. Paul to the mouth of the Missouri. He states that the probable high costs would perhaps prevent the entire system from ever being constructed, but admits that the water-power interests would probably contribute liberally to its execution. Experience has shown that the prospective cost of reservoir systems projected on unoccupied or practically unoccupied land has rarely been considered prohibitive, even if measured by the benefits to water power alone where the market for power is ample. In the valleys of the tributaries listed in Mr. Durham's article, as well as in the valley of the Mississippi itself, power is already in great demand, and its future use will undoubtedly be manifoldly greater. Knowing the cost of the reservoirs already established and considering the benefits to water power, flood prevention, and navigation, one can conservatively estimate that the necessary expenditure, though enormous, would be an excellent investment.

A report on the effect of the Mississippi reservoirs on the river at St. Paul during the unexampled drought of 1910, by Robert Follansbee, district engineer, United States Geological Survey, in charge of operations in Minnesota, also contains valuable information.[1]

CHATTAHOOCHEE BASIN.

Chattahoochee River has been selected for special inquiry because it is a typical southern stream subject to great fluctuations in flow. The river rises in the Blue Ridge Mountains in Lumpkin, White, and Habersham Counties, Ga., near the northeast corner of the State, and flows southwesterly until it reaches the Alabama line at West Point, Ga., thence it flows southward, forming the western boundary of Georgia, until it reaches Apalachicola River at the southern boundary of the State. Its upper tributaries are Chestatee and Soque Rivers, which join the Chattahoochee in Hall and Habersham Counties, respectively. The basin of the Chattahoochee River, which is slightly larger than that of the Flint, is peculiarly narrow, especially for the portion in the mountain and plateau regions. It lies between two ridges higher than the country on either side, like two great levees rescuing its water from the many encroaching tributaries of the Tallulah, Broad, Oconee, Ocmulgee, and Flint Rivers on the south, and the Ocoee, Etowah, and Tallapoosa Rivers on the

[1] Printed as Appendix III.

north. The fall line is well defined at Columbus, Ga., where the river may be said to break through the southern rim of its plateau basin The greatest amount of fall after leaving the small headwater streams occurs at and immediately above Columbus. The mountain portion of the basin, above Gainesville, Ga., is largely in forests, and contains much land too steep for cultivation. The Piedmont Plateau and Coastal Plain areas are mostly cleared.

The Chattahoochee affords extensive water powers and is navigable from Columbus, Ga., to the mouth of Flint River, a distance of 223 miles. Below the mouth of Flint River the Apalachicola extends 137 miles to the Gulf of Mexico. The present navigation project contemplates a low-water depth of 4 feet (which, however, is not maintained) from Columbus to the mouth of the Flint, and thence to the Gulf, a low-water depth of 6 feet. In 1908, 121,717 tons of merchandise, valued at $12,000,000, were transported on Chattahoochee and Flint Rivers.

Probably the greatest need of the Chattahoochee is increased depth during low-water seasons and unobstructed channel. As the river at Columbus, Ga., is only 190 feet above sea level, and the distance from this point to the Gulf is 360 miles, the slope must be very low. The slope of the Apalachicola is only 3 inches to the mile. Consequently both rivers flow with relatively low velocity, and the addition of a comparatively small amount of water from reservoirs will appreciably increase their depth. The river, therefore, holds promise for reservoir construction as an aid to navigation.

The basin of the Chattahoochee contains a large number of good reservoir sites; but if original storage capacity and permanent value of reservoirs are to be maintained, sites should be selected whose contributing basins are well protected by vegetation. Stripped of their forest cover, many parts of the basin of the upper Chattahoochee have been greatly eroded, and the capacity of some of the existing reservoirs on the main stream has been much reduced by material washed from the bare hillsides into the tributary streams and then deposited behind the dams. When carried farther downstream, such waste tends to seriously obstruct navigation.[1]

To determine the probable effect of the proposed reservoirs on the regimen of the Chattahoochee a study has been made of the records of flow at West Point, Ga., where a gauging station has been maintained since 1896. This station is located at the head of a series of falls and rapids ending at Columbus, Ga., 35 miles below. The total fall in this distance is about 360 feet. The effect of reservoirs on this stretch of the river is therefore of much interest in connection with powers. The drainage area above West Point is 3,300 square miles and the minimum discharge thus far recorded is 800 second-feet. Flood discharges of 50,000 second-feet are common. The discharge at West Point covering the period of record is shown by a mass-curve diagram. (See sheet 3.) A mass curve is merely a graphic representation of the discharge of a river by summation. The curve is begun by plotting the total flow for the first day, week, month, or any other suitable unit period. In the curve here discussed the month is the unit period. To the flow of the first month that of the second is added, and to the sum of

[1] Glenn, L. C., Denudation and Erosion in the Southern Appalachian Region and the Monongahela Basin: Prof. Paper U. S. Geol. Survey No. 72, 1911, pp. 96-100.

these two the flow of the third, and so on throughout the entire record. The Chattahoochee curve (sheet 3) shows that the total flow for the period August 6, 1896, to January, 1910, is a little more than 59,000,000 acre-feet, i. e., sufficient to cover 59,000,000 acres

to a depth of 1 foot. The mass curve shows not only the total volume of water at any designated time, but it also shows the relative rate at which the water was delivered from month to month, indicating clearly the periods of large and small flow.

Accompanying this curve is a vector diagram, showing the slope of the lines corresponding to a discharge of 3,000, 4,000, 5,000, and 6,000 second-feet, respectively. The vector diagram may be simply explained by saying that if the mass curve of any river were a straight line taking the direction of, say, the 3,000-second-foot vector, then that river would have a uniform flow of 3,000 second-feet all the year round. The fact that the mass curve of the Chattahoochee is crooked shows that its flow is not uniform, being at times less and at other times more than 3,000 second-feet.

Now, the purpose of reservoirs is to increase uniformity of flow. The reservoirs catch the surplus water of floods and thereby diminish the excess of flood over the uniform rate, and they release water to augment the natural low-water flow. Few streams can be so controlled that their flow will be absolutely uniform and still fewer would yield results justifying the necessary expenditure. To determine the degree of uniformity that may economically be realized the mass curve and its accompanying vectors serve better than any other method yet devised. The straight lines extending from the "humps" on the Chattahoochee curve and crossing that curve again at various distances above and to the right run parallel to the 3,000-second-foot vector. They tell the story as follows: Starting at the first "hump," which corresponds to the month of November, 1897, the vector again joins the curve in May, 1898. During the intervening period the natural flow of the Chattahoochee was not sufficient to maintain a uniform flow of 3,000 second-feet. What should be the capacity of the reservoirs in the drainage area in order to maintain this flow during the period, assuming that they were full at the start? This capacity is conveniently shown by the maximum departure of the mass curve from the 3,000-second-foot vector, or, in other words, by the length of the longest vertical line or ordinate between the vector and the curve. This ordinate corresponds to the month of March, 1898. By comparing its length with the scale on the left of the sheet it is found that it corresponds to about 300,000 acre-feet. This, then, is the storage that would have been necessary to compensate for the shortage of water during the dry period, November, 1897, to May, 1898, and maintain the Chattahoochee at West Point at a flow not less than 3,000 second-feet. During this period the water in the reservoirs would have been drawn lower and lower, though not at a uniform rate, until March, 1898, after which the reservoirs would have gradually filled. Of course the rate of inflow and outflow would have varied considerably at the several reservoirs.

Several subsequent periods of water shortage are also shown on sheet 3. The next two—from October, 1899, to January, 1900, and from May, 1902, to December, 1902—were comparatively insignificant, as shown by the small departures of vector and curve. The reservoir capacity provided for the first period of shortage—that is, from November, 1897, to May, 1898—would have been more than sufficient to cover the two later periods. The fourth period of shortage begins in the month of September, 1903, and ends in April, 1904, and a fifth begins in August, 1904, and ends in February, 1905. The maximum departure in both of these periods is less than that in the first period, although if fourth and fifth are considered together, the aggregate period of shortage is longer. It therefore appears that the maximum storage capacity required on the basin of Chattahoo-

chee River above West Point to insure a minimum flow of not less than 3,000 second-feet is about 300,000 acre-feet.

The record should also be examined to determine whether diversity of conditions of flow during the period of record, August 6, 1896, to January 1, 1910, was sufficiently great to justify the adoption of 300,000 acre-feet as a reasonable limit of storage under any probable conditions. It is obvious that if the record indicates no period of extreme low water a reservoir system whose capacity is based on the records might, in a later and longer dry period, prove insufficient to sustain the river at 3,000 second-feet at West Point. Fortunately, however, the record covers two excessively dry periods. Between the interval of August, 1903, and January, 1905, the river at West Point was probably as low as it will ever be. Experience has shown that predictions of this kind are not absolutely safe, but the flow during the period above mentioned was so extremely low that its assumption as the absolute minimum is safer than the assumption of the prospective safety of any business enterprise that now holds public confidence.

It has been indicated that an effective storage capacity of 300,000 acre-feet will maintain the Chattahoochee at a flow of not less than 3,000 second-feet at West Point. The extent of improvement possible under a system of controlled flow is suggested by the following condensed statement of low-water periods during the term of record:

Minimum flow and length of low-water periods in Chattahoochee River at West Point, 1897–1909.

Year.	Lowest flow.	Number of days below 3,000 second-feet.	Year.	Lowest flow.	Number of days below 3,000 second feet.
	Second-feet.			*Second-feet.*	
1897	845	175	1904	800	242
1898	900	149	1905	1,090	183
1899	930	115	1906	2,530	10
1900	2,100	29	1907	1,490	107
1901	2,380	30	1908	1,490	109
1902	1,000	125	1909	1,130	70
1903	1,840	121			

No final surveys have been made to determine whether the storage capacity of Chattahoochee Basin is sufficient to provide the necessary 300,000 acre-feet required, but data derived from general topographic surveys indicate that the capacity of the available sites is far greater than that required. The reservoir sites identified are listed in the following table. Probably detail surveys would show that some of the estimated capacities are probably too large and that others are too small, but the plus and minus errors would probably compensate in some degree, so that the net result of statements in the table is sufficiently accurate to give assurance of the practicability of the reservoir scheme on the Chattahoochee. Detail surveys would undoubtedly discover other reservoir sites in the basin not listed in the table and might also indicate that some of the listed sites are not as good as others now unknown.

Location.	Drainage area.	Mean annual run-off.	Assumed maximum run-off.	Area of reservoir.	Height of dam.	Capacity or reservoir.
	Sq. miles.	*Acre-feet.*	*Acre-feet.*	*Acres.*	*Feet.*	*Acre-feet.*
Soque River at Soque	21	28,900	41,000	512	80	18,000
Soque River above Clarksville	39	53,600	76,200	2,050	90	81,200
Nacoochee Valley	108	149,000	211,000	3,840	100	169,000
White Creek 1 mile above mouth	9.5	13,100	18,600	3,840	85	144,000
Mossy Creek 1 mile above county line	28	38,500	54,700	526	70	16,200
Tesnatee Creek 4 miles above mouth	54	74,300	106,000	1,090	80	38,400
Chestatee River at Willow	41	56,400	80,100	512	40	9,010
Chestatee River east of Dahlonega	53	72,900	104,000	2,380	100	105,000
Little River 1 mile above mouth	31	42,600	60,600	526	50	11,600
Wahoo Creek 2 miles above mouth	29	39,900	56,700	1,860	50	40,900
Yellow Creek	17	23,400	33,200	1,220	40	21,500
Big Creek	95	131,000	186,000	2,300	75	75,900
Chattahoochee River north of Gainesville	153	210,000	299,000	11,100	140	559,000

In considering the aggregate capacity of the sites listed in the above table the mean annual run-off is used in order to eliminate the effect of using certain years of maximum run-off which would undoubtedly indicate a larger degree of compensation at low-water periods than can actually be secured. The amount used is 1.9 cubic feet per second per square mile, which is approximately the mean for the entire period of record at West Point. In computing the capacity of the reservoirs the mean annual run-off has been used for sites having capacity greater than the run-off; for sites whose capacity is less than the run-off that capacity is used. The result is as follows:

Capacity of reservoir sites in Chattahoochee River Basin.

River.	Capacity.
	Acre-feet.
Soque River at Soque	18,000
Soque River above Clarksville	53,600
Nacoochee Valley	149,000
White Creek	13,100
Mossy Creek	16,200
Tesnatee Creek	38,400
Chestatee River at Willow	9,010
Chestatee River east of Dahlonega	72,900
Little River	11,600
Wahoo Creek	39,900
Yellow Creek	21,500
Big Creek	75,900
Chattahoochee River north of Gainesville	210,000
Total	729,110

The foregoing table shows that the aggregate capacity is about two and one-third times that necessary to maintain the Chattahoochee at not less than 3,000 second-feet at West Point. A further calculation, not here recorded, shows that the aggregate capacity is not sufficient to maintain the Chattahoochee at 4,000 second-feet. The actual capacity lies somewhere between 3,000 and 4,000 second-feet, probably about 3,500 second-feet. The amount could readily be determined, but inasmuch as the reservoir capacities given are approximate, the computations need be carried not further at this time. It is merely assumed that it is possible to secure more than 3,000 second-feet.

The effect of a discharge of 3,000 second-feet at West Point on the navigable channel of the Chattahoochee below Columbus can not be

determined closely with the data at hand. It depends largely on the amount of water contributed by that portion of the Chattahoochee drainage below West Point. If this amount be large because of heavy local rainfall not received by the drainage area above West Point then the stage of the river below Columbus will be relatively higher than would be indicated by the stage at West Point. The converse of this is also true. A comparison has been made of the stages at West Point, Ga., and at Eufaula, Ala., where a river gauge has been maintained for many years by the United States Weather Bureau. In making this comparison the stage of one day at West Point has been compared with that of the following day at Eufaula, it being assumed that the distance between the two points is equivalent to one day's rate of flow—an assumption that is probably sufficiently accurate to serve the purpose here considered. When the discharge at West Point is 3,000 second-feet the gauge at that place reads 2.8 feet.

A review of the records at the Eufaula gauge shows that when the stage is 2.8 at West Point the stage at Eufaula varies generally from 2 to 4 feet, the average being approximately 2.8. On six occasions only since 1896 has the Eufaula gauge recorded a stage below 2 feet when the gauge at West Point read 2.8 feet; on nine occasions it has been above 4 feet with a 2.8 gauge at West Point, the highest being 6.4 feet. The relation of river stage at Eufaula to the navigability of the Chattahoochee could not be ascertained in time to be stated in this report. The point can be fully considered if the Waterways Commission finds it desirable to pursue this matter further. Inspection of the Eufaula gauge records shows that the stage is frequently below 0 and for considerable periods is 1 foot or less. The average addition to low-water stage at Eufaula by maintenance of stage at West Point so that it will not fall below 2.8 appears to be about 2 feet. What change would be effected along the entire course of the river remains to be determined, but it is apparent that the proposed improvement would be of great value to navigation.

WATER POWER.

The establishment of the reservoir system here proposed, or its equivalent, would have very beneficial effects on the water-power resources of the Chattahoochee Basin. The minimum low-water flow at West Point is 800 second-feet. The greatest power privilege on the stream is at the rapids between West Point and Columbus, referred to on a previous page. The effect of increased low-water flow on this power is here discussed in order to indicate the degree of improvement to the power projects. In this discussion the minimum flow, which measures the primary or the dependable power, is used as a basis. The horsepower theoretically available over 360 feet, with a flow of 800 second-feet, is about 24,900. That which would be available under the reservoir improvement would be about 93,300, or an addition of 68,400 horsepower along this reach. Similar increase would, of course, be effected at certain power sites above West Point. If it be assumed that along the West Point-Columbus reach the ultimate value of power will be $20 per horsepower-year, the annual value of the added power would be $1,368,000. This amount, capitalized at 15 per cent, equals $9,120,000, which repre-

sents the value of the improvement of water powers in this single reach of river. A very considerable part of the power privilege has already been developed. Naturally the capacity of wheels installed is largely in excess of the minimum flow. It is probable that an increase as above specified would not involve the established power companies in a large expenditure for new equipment. The gain in power would therefore be a net gain in value. The situation for the remainder of the privilege, not yet developed, would be the same. It is not believed that the prospective power beneficiaries under the reservoir scheme would fail to enter an agreement to sustain their proper proportion of the reservoir costs if construction were made contingent on such participation. The case, therefore, presents a good example of possibilities of cooperation between the Federal Government and private parties.

FLOODS.

The foregoing discussion relates to the maintenance of a stage at West Point always equivalent to 3,000 second-feet or more. In other words, it provides for the relief of extreme low-water conditions. The prevention of floods is quite another consideration, and sufficient data are not at hand to show even approximately what the net result of the establishment of a 700,000 acre-foot capacity would be. It would not be possible by the use of these reservoirs to prevent floods. In the first place, the capacity is not sufficient to accomplish this purpose, and, in the second place, the reservoirs are located high up on the drainage area and there is sufficient catchment basin below to give rise to floods, which, of course, the reservoirs would affect in no degree. It has been shown that about 300,000 acre-feet are needed for the maintenance of the 3,000 second-foot stage at West Point. The remaining 400,000 acre-feet could be used for partial flood prevention. There is no doubt that it would have some very beneficial effects, although it would not give complete control except under fortunate conditions, such as when the floods are all derived from the upper headwaters. It is self-evident that a more mature investigation of the whole matter is advisable, even were the water-power and navigation considerations not an important part of the scheme.

OHIO RIVER BASIN.

The general subject of reservoir projects in the Ohio Basin was discussed by the writer in his report to the Inland Waterways Commission. Since that report was submitted two investigations have been made, the first comprising a detail survey of the reservoir sites in the Allegheny and Monongahela Basins and a study of the probable effect of reservoirs on floods at Pittsburgh, the second comprising general studies of run-off and reservoir sites, without detail survey, in the basins of New and Greenbrier Rivers, tributaries of the Kanawha.

The Monongahela surveys and studies have been carried on by the Pittsburgh Flood Commission for more than two years. The work is not quite completed, and as the commission intends to submit a copy of its report to the National Waterways Commission, only brief reference to the work will here be made. In response to a request

for a general statement of the probable results of the investigation, the flood commission wrote a letter from which the following quotation is made:

In accordance with your request for a general statement as to the effectiveness of reservoirs, we have pleasure in saying that the results ascertained are very satisfactory; in fact, beyond the early expectations, and fully sustain your pioneer conception [1] of the possibilities of flood water storage.

The work has been conducted in a most thorough manner, not only throughout the drainage basin, but in the city and vicinity. The surveys covered parts of many of the tributaries of both the Allegheny and Monongahela Basins, and show that a very considerable number of efficient reservoir sites exist. Later study, while not in complete or final form, demonstrates that flood control by reservoirs at Pittsburgh is feasible, practically to below danger line, and that portions here and there of low-lying river banks consisting of lands of lesser value would have to be raised or protected by comparatively low walls or embankments.

In connection with studies on the Monongahela, certain work of the Pittsburgh Hydroelectric Power Co. is of interest, because it indicates how effectively a small amount of storage would improve the low-water flow of the Monongahela at Pittsburgh; and how much more might be accomplished by a complete system of reservoirs.

The investigations were made in the basin of Big Sandy Creek, a tributary of Cheat River, draining an area comprising only 220 square miles. The project involves the development of water power at a point near the mouth of the river by means of a high-line canal leading from a storage reservoir about 1 mile above. The minimum flow at the diversion point is about 10 second-feet. The plans propose three main storage reservoirs, having an aggregate capacity of 102,400 acre-feet, and three other reservoirs to catch and hold the excess run-off during very wet years. The three main reservoirs would absolutely control the flow of Big Sandy Creek, and the uniform distribution of the water throughout the year would increase the low-water flow from 10 to 300 second-feet. The needs of the power plants would probably be best met by providing a uniform discharge or a discharge varying only within narrow limits corresponding with the daily fluctuations in power demand, but such a discharge would not afford the maximum benefit to the Monongahela. To aid navigation it would be better to hold back the water during high-stage seasons and release it in larger quantities during low-stage periods on the Monongahela. The uniform discharge of the Big Sandy Creek water, most favorable to power plants, would nevertheless distinctly benefit the conditions of flow at Pittsburgh.

The records of the United States Engineer Office show that the minimum flow of the Monongahela at Pittsburgh was 166 second-feet in 1895. The usual low-water flow is about 200 second-feet. Deducting from the latter the low-season contribution of Big Sandy Creek there remains about 190 second-feet derived from the remainder of the drainage area. Adding to this the regulated flow of Big Sandy Creek 300 second-feet, gives a total of 490 second-feet, or nearly two and one-half times the low-water flow at Pittsburgh.

It should be remembered that the drainage area of Big Sandy Creek is only 220 square miles in extent; that of the Monongahela above Pittsburgh is 7,360 square miles. If reservoir conservation on so minute a fraction of the Monongahela Basin will produce such marked results, the utilization of even a small part of the reservoir facilities

[1] This refers to the writer's report to the Inland Waterways Commission.

available in the entire basin can not fail to yield proportionately larger benefits.

The Big Sandy Creek project serves merely as an interesting suggestion. The Waterways Commission will be provided with further facts concerning the Monongahela area by the Pittsburgh Flood Commission.

KANAWHA BASIN.

In his former report to the Inland Waterways Commission and again in a report to the Forest Service,[1] the writer suggested that the money expended for the erection and maintenance of the system of movable dams on Kanawha River could have been more purposefully used for storage reservoirs on the highland tributaries, and attempted to show approximately that by the development of storage sites at 17 designated points on all the important tributaries a navigable stage along the now canalized portion of the river could probably be maintained. He also suggested that the increase in power values in the upper Kanawha, the benefits to navigation that would accrue in certain portions of Ohio River proper, and the large measure of flood relief afforded would be amply sufficient to warrant a very large expenditure for the reservoir system. His further observations and studies support the opinions then advanced. The present studies do not cover the entire Kanawha Basin, being confined to the Kanawha at Kanawha Falls and Lock 4 and to the New and Greenbrier drainage areas, yet they give assurance of efficiency in regulation which surpasses that predicted in the previous report. In the opinion of the writer the statements originally made were too conservative. It appears reasonable to believe, as will be shown further on, that if certain channel improvements be performed at a few critical points, a navigable stage could be maintained by release of stored water from the New and Greenbrier Basins alone.

In endeavoring to determine the deficiencies in flow of the Kanawha that render it necessary to operate the system of movable dams it has been found that the most direct relation between the minimum stage of open navigation along any given stretch of river and a well-rated cross section of the river is expressed by the relation of the gauge record at Kanawha Falls to the operation of Lock 4. This lock, which is the highest on the Kanawha River equipped with a movable dam, is located 21 miles below Kanawha Falls. Between the lock and the falls the area tributary to the Kanawha is about 400 square miles. The records of gauge height at Charleston, W. Va., and their relation to Lock 6 might be used; but as an index to volume of flow the Charleston records are not considered as trustworthy as those at Kanawha Falls, especially as the former are complicated by dam operation. Therefore present considerations will be confined to the Lock 4 pool.

A study has been made of the records of operation of the Kanawha River movable dams furnished by the engineer officer in charge through the courtesy of the Chief of Engineers, United States Army. The dams are in general operated coincidently, although, as might be expected, the records indicate that a dam or two may be raised or lowered at times when other dams are not operated. The tributaries of the Kanawha are large, and it is easy to understand that a low rate

[1] Printed as Forest Service Circular No. 143.

of run-off from the drainage area above Charleston, for example, might necessitate the raising of movable Dams Nos. 4 and 5, which are above that city, while at the same time a sufficient flow might be brought in by Elk River, which enters the Kanawha at Charleston, to maintain a suitable open-river stage below that point for a brief period. Many such combinations of circumstances may locally affect dam operation; but as a whole it may be said that outside of these local modifications the coincidence of operation is practically fixed. A study of the operation of Lock 4 shows that the stage at which the dam is raised is not entirely uniform. Sometimes it has been raised with the gauge at Kanawha Falls reading as high as 3.8; at other times it has not been found necessary to raise the dam until the Kanawha Falls gauge has dropped to 2.2. During the years 1896 to 1910 the average stage at Kanawha Falls at which the dam at Lock 4 has been raised is 3.07 feet. For practical purposes in subsequent calculations an even stage of 3 feet is assumed. This gauge height corresponds to a flow of 8,200 second-feet at Kanawha Falls.

By noting the stages below 3 feet during the periods at which the dam at Lock 4 has been raised, the deficiency in flow below the critical point of open navigation in Lock 4 pool can be approximately determined—that is, assuming that the dam at Lock 4 would never have to be raised if the stage at Kanawha Falls never dropped below 3 feet, the equivalent in flow that would have been necessary to keep the stage at Kanawha Falls up to 8,200 second-feet represents approximately the amount of water that would have to be supplied to the river from storage in order to eliminate the necessity of operation of Lock 4. Of course, such a computation is approximate, even as is the stage at which the dams are operated. It is also probable that the dams lower down on the stream might have to be operated on a different schedule. A greater discharge than 8,200 second-feet might be necessary to eliminate operation of some of the lower locks; but it should be remembered that there are other tributaries entering the Kanawha below the falls and storage reservoirs on them would compensate all such deficiencies, as will be indicated in the following paragraphs. All this is a matter for subsequent study, as sufficient data are not at hand to make an absolute determination.

Before taking up this computation, the available storage capacity above Kanawha Falls should be considered. The drainage area above this point embraces 8,330 square miles and contains many feasible reservoir sites on the main stream as well as on the numerous tributaries. As already stated, the present report will consider only reservoir sites on New River above Radford, Va., and on the Greenbrier above Alderson, W. Va. If it can be shown that the utilization of the available storage sites on these two areas will obviate, or even nearly obviate, the necessity of operating Lock 4, there can be no question concerning the beneficial effect on all the river below of establishing conservation reservoirs at suitable places on other tributaries not here considered. For both streams it will be assumed that the limiting reservoir capacity is that which would maintain the greatest possible uniformity of flow at the gauging station during the period of record covered by the mass curve. It is not implied that the release of the stored waters in such a way as to secure the highest degree of uniformity of flow will be the most beneficial way. Obviously, the use for which the water is intended will determine the best

schedule. Storage on the Greenbrier would be made most beneficial by releasing the water in a manner to compensate for low-water seasons in the Kanawha below. The same is true with respect to the New at Radford, though both below and above this point water-power considerations would complicate the problem. The most productive distribution would necessarily be a matter for mature study, but for the purposes of this report it will be assumed that navigation is the higher use and that the release of the stored water will be regulated to serve navigation. Even under such a schedule, however, the residual benefit to power would, on the whole, be very large.

GREENBRIER RIVER.

The yield of Greenbrier Basin above Alderson will first be considered in order to determine the storage capacity necessary to control the flow at that point. The drainage area above Alderson is 1,340 square miles.

Sheet 4 shows a mass curve of flow of Greenbrier River at Alderson, for the period August, 1896, to December, 1909. From July, 1906, to May, 1907, inclusive, the gauging station was not maintained, and the curve has therefore been made by omitting the year beginning July 1. It is impossible to determine precisely the resultant departure of the curve from its proper course, but data for this year derived from observations at other points indicate no unusual departure from normal conditions. The important year of record is 1904, the dryness of which was practically unprecedented. So long as this year is included in the record the determination of the necessary capacity of the reservoirs is not materially affected.

In general make-up sheet 5 resembles sheet 4. The vector plotted corresponds to a flow of 1,900 second-feet. The maximum departure of the curve, shown at D, occurs in January, 1905, immediately following the very dry season of 1904. It is equivalent to 1,200,000 acre-feet; that is, a reservoir of that capacity would maintain the flow of the Greenbrier at Alderson at not less than 1,900 second-feet during the driest period recorded. Facts concerning certain available reservoir sites in the Greenbrier Basin are given in the following table. The basin contains many other sites which detailed investigation might prove more suitable than some here described, but those listed will absolutely control the discharge from 1,220 of the 1,340 square miles of the Greenbrier Basin above Alderson. All have capacities far in excess of the mean annual run-off in the basin above, and all but two have capacities in excess of the assumed maximum, and of one of the two—the West Fork reservoir—the excess could be amply stored in the Cloverlick reservoir. The only reservoir that would actually lose any water in a year of maximum run-off is that on the main stream opposite Lewisburg. Altogether Greenbrier Basin affords most unusual opportunities for storage. The total effective capacity for the year of mean run-off is 1,330,600 acre-feet, or more than 130,000 acre-feet in excess of the amount required to maintain the flow at Alderson at 1,900 second-feet.

Location.	Drainage area.	Mean annual run-off.	Assumed maximum run-off.	Area of reservoir.	Height of dam.	Capacity of reservoir.
	Sq. miles.	*Acre-feet.*	*Acre-feet.*	*Acres.*	*Feet.*	*Acre-feet.*
Second Creek, No. 1, at Eads Ridge	58	63,000	106,000	3,904	200	258,000
Howards Creek Dam, 1.8 miles above mouth	85	92,300	154,000	5,250	160	370,000
Anthonys Creek, about 1.5 miles below Little	139	151,000	252,000	5,784	200	463,000
Knapps Creek, 5 miles below junction with Laurel Creek	74	80,400	134,000	9,220	150	608,000
Thorny Creek, 2 miles above mouth	11	11,900	19,900	3,904	100	172,000
Thomas Creek, 1.2 miles above mouth	54	58,600	97,700	4,480	120	210,000
Deer Creek, 2 miles above mouth	73	79,300	132,000	6,080	180	482,000
East Fork of Greenbrier River, 1 mile above mouth	68	73,800	123,000	1,792	160	126,000
West Fork of Greenbrier River	62	67,300	112,000	1,344	160	71,000
Greenbrier River at Cloverlick	[1] 63	69,000	115,000	4,700	177	366,000
Greenbrier River at Lewisburg	[1] 533	584,000	1,013,000	11,600	164	666,000

[1] Net area.

It will be observed, on examination of the foregoing table, that all of the proposed reservoirs except two are capable of being developed to a capacity far in excess of the assumed maximum run-off. Considerable latitude may, therefore, be allowed in fixing the height of dams and adjusting the capacities to conform with the most economical storage. It will also be noted that two run-off bases are considered: First, the mean annual run-off, 1.5 cubic feet per second per square mile, which is estimated on records obtained at the Alderson station; on this basis it is necessary to determine the minimum storage that may be effected in connection with any water-supply developments. Second, the maximum annual run-off per square mile; the records show 2.11 cubic feet per second, but as a safeguard in subsequent discussion of flood regulation the maximum is assumed as 2.5 cubic feet per second per square mile, or 0.39 second-foot per square mile greater than has ever been observed. If the storage sites satisfy this maximum, the results can be accepted with an unusual degree of confidence. The principal facts in relation to the various storage reservoirs listed in the table are presented in the following paragraphs:

Second Creek sites.—The basin of Second Creek, 58 square miles in extent, affords two reservoir sites. The upper one, with dam site at the gorge running through Middle Mountain, is probably the best from the point of view of the engineer; the lower one, with dam site at Eads Ridge, would best control the greater proportion of storage area. The table shows that a 200-foot dam at the lower site would afford a capacity of 258,000 acre-feet, which is more than four times the mean annual run-off and about two and a half times the assumed maximum. Therefore, a lower dam could safely be constructed. Moreover, the land that this reservoir would cover is not especially valuable; no railroads cross it, nor does it contain important settlements; therefore, flowage damages would not be excessive. It is apparent that the run-off from the 58 square miles drained by Second Creek can be absolutely controlled, even during a year of higher flow than has ever yet been recorded at Alderson.

Howard Creek Reservoir.—Howard Creek enters the Greenbrier opposite Louisville. The dam site is located in a gorge about 2 miles above the mouth. Back of this gorge is a broad basin, evidently well suited for a reservoir site. The table shows a capacity, with a dam 160 feet high, of 370,000 acre-feet, or more than four times the run-off

for the average year and nearly three times the maximum run-off. Therefore a dam considerably lower than 160 feet would suffice to control the entire flow of this tributary, and at full development it would hold all the supply over a series of years. This reservoir would be quite expensive on account of land damages. The Chesapeake & Ohio Railroad tracks traverse the greater part of the reservoir bottom, and would have to be diverted along an alternate route, which, however, does not appear to offer many difficulties. A small settlement known as White Sulphur Springs occupies the bottom of the site. Probably the proper adjustment of height of dam to the necessary capacity would reduce the flowage damages. The run-off of the 83 square miles of country drained by Howard Creek drainage is subject to control.

Anthonys Creek site.—The dam site for the proposed reservoir on Anthonys Creek is at the south end of Hopkins Mountain, where the river enters the gorge. The drainage area is 139 square miles, and three times the mean annual run-off, or nearly twice the assumed maximum, could be controlled by a dam 200 feet high. Therefore the proposed dam is higher than necessary, and suitable adjustment may be made upon further study. It is evident that the Anthonys Creek area is subject to absolute control. The basin contains no railroads nor important settlements and the damages would be principally those due to the inundation of agricultural lands.

Knapp Creek.—The run-off from 74 square miles of the upland portion of the Knapp Creek drainage area can be absolutely controlled. A dam 150 feet high would afford a storage capacity of over 600,000 acre-feet, or more than seven times the mean annual run-off in the drainage area and nearly five times the maximum run-off. A suitable study and survey would show the most economical method of developing this area.

Thorny Creek.—A drainage area comprising 11 square miles is under control of a dam site in the gorge between Marlin Mountain and Thorny Creek Mountain. As the storage capacity with dam 100 feet high is nearly 15 times the mean annual run-off, it is probable that a very low dam would conserve the maximum run-off. It is doubtful whether the drainage area is large enough to make the plan feasible; the site has been included in the table merely to show that 11 square miles more of the drainage basin of the Greenbrier are subject to absolute control.

Thomas Creek.—A dam 100 feet high across the river in the gorge between Thomas Mountain and Peters Mountain will afford a storage capacity of 210,000 acre-feet, which is nearly four times the mean annual run-off and more than twice the assumed maximum. The drainage area is 54 square miles in extent. A lower dam than that specified in the above table would therefore economically suit all purposes.

Deer Creek.—The drainage area of Deer Creek above the dam site between Little Mountain and Peters Mountain comprises 73 square miles and the capacity of the reservoir is more than six times the mean annual run-off and nearly four times the assumed maximum. This drainage area is therefore subject to absolute control.

East Fork of Greenbrier River.—One mile above the mouth of the East Fork a dam 160 feet high would afford a storage capacity of 126,000 acre-feet. The mean annual run-off from the 68 square

miles of tributary drainage area is 73,800 acre-feet; the maximum is 123,000 acre-feet, or 3,000 feet less than the capacity. This portion of the Greenbrier is therefore subject to absolute control.

West Fork of Greenbrier River.—A 160-foot dam on the West Fork, about 1½ miles above its junction with the East Fork, would store 71,000 acre-feet, which is nearly 4,000 acre-feet more than the mean annual run-off, or 41,000 acre-feet less than the assumed maximum. Sixty-two square miles of this drainage area are therefore subject to absolute control for mean annual run-off, and, as will be shown below, the excess of very wet years may be held in Cloverlick Reservoir.

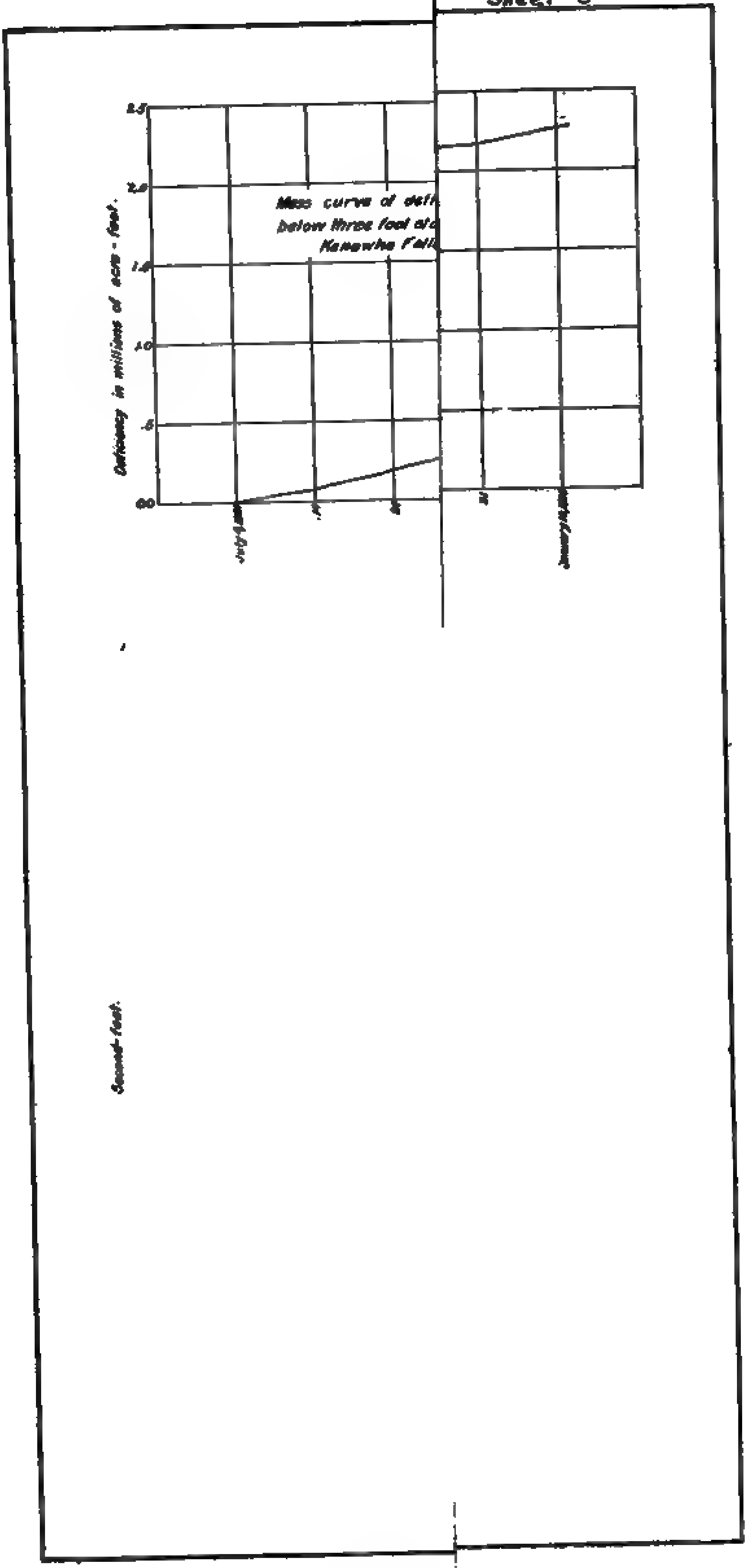
Sites on Greenbrier River proper.—On the Greenbrier proper are several reservoir sites, two of which have been selected for discussion at this time. The first involves a dam near Cloverlick at a point just below the mouth of Laurel Run. Above this point the drainage area is 320 square miles. It will be seen from the table that the capacity of the reservoir is 366,000 acre-feet, or 18,000 acre-feet more than the mean annual run-off; but the capacity is, moreover, 213,000 acre-feet less than the assumed maximum run-off. Lying above this site are the sites on the east and west forks and on Thomas and Deer Creeks. With the areas of these four sites eliminated, the net area above Greenbrier site here discussed is only 63 square miles. Therefore the whole matter should receive special study. Whether or not it would be better to build the single large reservoir on Greenbrier River than the four smaller ones on the drainage area above can be determined only after survey and careful estimate. In any event, the entire annual flow from the upper 320 square miles of Greenbrier drainage can be absolutely controlled throughout the maximum year that is ever likely to occur in that area.

Lewisburg reservoir.—The second dam site on the main stream is about 2 miles above the mouth of Howards Creek and immediately east of Lewisburg, W. Va. At that point a dam 164 feet high would afford a reservoir of capacity 666,000 acre-feet. The net drainage area above this point; that is, the total area less the tributary areas above, already provided for, is 533 square miles. Absolute control is possible except for the very wet years.

NEW RIVER ABOVE RADFORD.

Records of New River flow are available at Radford, Va., since August, 1898, with the exception of the year July 1, 1906, to June 30, 1907. The mass curve (sheet 5) of the flow of New River at Radford is continued from the end of one year to the beginning of the next, as though the year had not intervened. The curve shows that a flow of 6,000 cubic feet per second would be maintained for the greater part of the time with a comparatively small amount of storage. The critical period is 1904, and to maintain a flow of 4,000 cubic feet per second throughout that long period of drought would require, as shown by the maximum departure of the curve from the 4,000 second-feet vector in January, 1905, a storage capacity of 1,400,000 acre-feet. A storage capacity of 1,800,000 acre-feet is readily available in the New River Basin above Radford. Much more is probably available, but this amount will for the present be considered the practicable limit. The location and other important facts concerning certain reservoir sites in the area are given in the fol-

Sheet 6



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lowing table. The mean annual run-off is based on an observed mean of 2 second-feet per square mile; the assumed maximum, 3.5 second-feet per square mile, is slightly in excess of the highest run-off recorded. The aggregate effective capacity is based on the values in column 7, except for Chestnut Creek Reservoir, which is the only one whose capacity exceeds the mean annual run-off. The table indicates that although the basin is well supplied with reservoir sites, it does not compare with the basin of the Greenbrier in relative capacity nor in the unit size of the sites.

Location.	Drainage area.	Mean annual run-off.	Assumed maximum run-off.	Area of reservoir.	Height of dam.	Capacity of reservoir.
	Sq. miles.	*Acre-feet.*	*Acre-feet.*	*Acres.*	*Feet.*	*Acre-feet.*
Little River 1 mile above mouth	290	420,000	735,000	4,610	150	304,000
Pea Creek 2 miles above mouth	81	117,000	206,000	1,860	60	49,100
North Fork of Pea Creek	17	24,600	43,100	1,020	50	22,400
Big Reed Island Creek 2 miles above mouth	380	550,000	953,000	2,800	100	104,000
Little Reed Island Creek above Rock Creek	60	86,900	153,000	1,470	100	51,400
Chestnut Creek 2 miles above Mill Creek	45	65,200	114,000	2,940	100	129,000
New River at Farmer Mountain	508	736,000	1,290,000	6,200	200	546,000
Reed Creek 2 miles above mouth	107	155,000	271,000	4,500	100	198,000
Reed Creek above Wytheville	124	180,000	314,000	1,790	60	47,300
Reed Creek	19	27,500	48,100	512	70	15,800
Cripple Creek	180	261,000	456,000	2,000	100	88,000
Knob Fork 2 miles above mouth	19	27,500	48,100	832	70	25,600
Elk Creek headwaters	16	23,200	40,500	832	100	36,600
Peach Bottom Creek 3 miles above mouth	26	37,600	65,900	768	60	20,300
Fox Creek headwaters	14.2	20,600	36,000	526	70	14,700
Wilson Creek 5 miles above mouth	31	44,900	78,600	960	80	30,700
New River at State boundary	358	518,000	907,000	1,730	90	51,400
North Fork of New River above Brushforks	17	24,600	43,100	320	80	9,220
South Fork of New River 1 mile above Elk Cross Roads	87	126,000	221,000	2,620	100	94,300
South Fork of New River above Nathan Creek	169	245,000	428,000	5,120	60	99,400

Detailed description of the sites in the above table will be unnecessary. It will be sufficient to note that the proposed reservoir system provides for the complete control of the run-off from 1,254 square miles of the entire 2,720 square miles above Radford, and assures total storage of 1,331,000 acre-feet in the Greenbrier Basin and of 1,817,000 acre-feet in the New; in all, 3,148,000 acre-feet.

The records show that the longest period during which the dam at Lock No. 4 was continuously raised was from July 4, 1904, to January 9, 1905, corresponding in time to the now historic dry period in that country and also to the period of greatest unit and aggregate deficiency of water flow. If the drainage basin of the Kanawha above Lock No. 4 affords sites for reservoirs large enough to have maintained the water at Kanawha Falls above the 3-foot stage during this period, the adequacy of such a reservoir system during shorter periods can not be questioned. The danger of the occurrence of a much prolonged period of deficient flow is small. In other words, this long period in 1904 probably affords as severe a test of the efficiency of the reservoirs as any to which they would ever be subjected.

Sheet 6 shows in diagrammatic form the deficiency in flow at Kanawha Falls from July 4, 1904, to January 9, 1905. Uniform flow at the 3-foot stage is represented by the horizontal line, representing a flow of 8,200 second-feet. The unbroken line shows the actual flow at Kanawha Falls during this period and represents a total deficiency of 1,920,000 acre-feet. But it must be remembered

that there is under absolute control in the New and Greenbrier Basins 2,474 square miles which must be deducted from the contributing area, because the run-off from this 2,474 square miles, being shut out of normal contribution, must be used to supply deficiencies. In other words, had the reservoirs been constructed and kept closed during this long period of operation, the flow at Kanawha Falls would have been less than it actually was. The broken line shows what the flow would have been under such circumstances. It is 70 per cent of the flow at the falls, the amount representing the proportion of uncontrolled area in the basin. At the top of the diagram is a mass curve of deficiency during the period; it represents the amount lying between the horizontal line of 8,200 second-feet and the broken line, and shows a deficiency of 2,280,000 acre-feet. The effective reservoir capacity available on the New and Greenbrier is, as before stated, 3,148,000 acre-feet, which is 868,000 acre-feet more than would have been needed to retain the water at Kanawha Falls up to the 3-foot stage. In fact, this excess provides a reasonable margin to cover the losses that would certainly be sustained in the practical regulation of the river. It would be impossible to handle the waters with perfect economy. If, therefore, the conservation of water on the Greenbrier and New alone would accomplish the purpose here sought, viz, the elimination of Lock No. 4, there remains little doubt that similar conservation on the Gauley, Elk, Cabin Point, Armstrong, and Long Creeks and other tributaries would accomplish the entire purpose throughout the canalized portion of the Kanawha.

For the purpose of testing the reasonableness of the foregoing assumption that the average stage at which the dam at Lock No. 4 is raised (3 feet at Kanawha Falls) is a fair indication of the minimum amount of water required to maintain the Lock No. 4 pool at navigable stage under open conditions, the following analysis has been made by Mr. R. H. Bolster, hydraulic engineer, United States Geological Survey.

A discharge of 8,200 second-feet at Kanawha Falls is equivalent to a gauge height of 9.1 feet at lower Lock No. 3 (that is at the upper end of pool No. 4) for conditions of free flow. How does this stage compare with that actually maintained by the raised dam at Lock No. 4 during the low-water period of 1904 which has been used in foregoing paragraphs as a measure of reservoir efficiency? During this period the gauge height at lower Lock No. 3 averaged 7.85 feet, corresponding to a discharge under open-flow conditions of 5,800 second-feet, or 2,400 second-feet less than that provided in the foregoing storage calculations. Furthermore, during the month of October, 1904, the gauge at lower Lock No. 3 recorded only 7.25 feet, equivalent to an open-river discharge of only 4,800 second-feet. In other words, during this month the raised dam at Lock No. 4 sustained at the upper end of pool No. 4 a depth which under conditions of free flow corresponded to a discharge of only about 60 per cent of that above allowed for reservoir operation. Instead of having in the upper end of pool No. 4 a stage corresponding to 8,200 second-feet, this dam maintained a stage corresponding to only 4,800 second-feet. Yet the stage maintained was a navigable stage. Can there be any doubt concerning the sufficiency of 8,200 second-feet at Kanawha Falls? Indeed, does it not appear that such an allowance is over liberal?

It may be argued that, though the effect at Lock No. 4 might be accomplished if the reservoirs were full at the beginning of the long period of operation, there is little or no assurance that the reservoirs would have been filled to capacity. Some study has been given to this point. In the first place, if these reservoirs were operated as an aid to navigation, they would not, in ordinary seasons of shortage, be greatly drawn down. Therefore the refilling will not require a very long period, especially in the rainy seasons. In order to test the matter for the year 1904, however, a combined mass curve of New and Greenbrier flow has been made and is shown on sheet 7. About the highest point on that curve is at *a*, corresponding with the month of September, 1903. An inspection of the curve leaves no doubt that the reservoirs would have been full at that time. A vector has been drawn from this point across to the apex of the next "hump," at point *b*, which corresponds to June, 1904. This vector represents a uniform discharge of 4,300 second-feet, and indicates that, had there been discharged from the reservoirs a uniform amount of 4,300 second-feet of water from September, 1903, to June, 1904, the reservoirs would have been full on the latter date. The maximun draft on the reservoirs, as shown by the length of the maximum ordinate during this period, would have been only a little more than 500,000 acre-feet. Now, during the year 1903 the dam at Lock 4 was operated for a continuous period of 159 days—that is, from July 5, to December 10. The deficiency represented was 1,430,000 acre-feet. A continuous flow of 4,300 second-feet from the reservoirs from the end of September, 1903, to the end of June, 1904, would be equivalent to a total discharge of 2,347,800 acre-feet, or more than 900,000 acre-feet in excess of that required to cover the deficiency period of 1903. Therefore, if with so great an excess of discharge the reservoirs would still be found full at the end of June, 1904, there can be no doubt of their being full had they been operated to discharge only the quantity required to eliminate the operation of Lock No. 4. The deficiencies lying between the two long periods of dam operation (1903 and 1904) are insignificant in amount and do not materially affect the foregoing estimates. They could all be amply supplied by a small part of the 900,000 acre-feet excess indicated.

If the reservoirs had been full on July 1, 1904, they would have supplied the discharge of 2,280,000 acre-feet required to cover the long period of deficiency from July 4, 1904, to January 8, 1905, and would have contained at the end of the period about 800,000 acre-feet of the water originally stored plus that which they would have caught up from the natural flow of the contributing streams during that time. An estimate of the quantity that would have been in storage on January 8, 1905, will be of interest.

The period of deficiency, July 4, 1904, to January 8, 1905, covers 188 days. A discharge of 2,280,000 acre-feet during that period corresponds to an average discharge of 6,063 second-feet. Projecting the vector corresponding to this discharge on the mass curve of sheet 8, from the point corresponding to July 4, 1904, designated as *c*, to that corresponding to January 8, designated as *d*, the depletion of the reservoirs at that time, as shown by the vertical distance of the point *d* from the mass curve, would have been 1,500,000 acre-feet; that is, there would have remained in the reservoirs the difference between this amount and their total capacity of 3,150,000 acre-feet, or 1,650,000

acre-feet. In other words, even after this long period of operation in 1904 and 1905, the reservoirs would have been more than half full. If the reservoirs were closed at that time and allowed to fill, they would have overflowed about May 1. The records of dam operation for 1905 show, however, that it was necessary to raise the dam at Lock No. 4 for a total period of 19 days previous to May 1 and subsequent to January 8. Compensation for this period would have required that the storage be drawn on to some extent. The actual deficiency during these 19 days was small. Therefore, it would probably have been nearly the 10th of May before the reservoirs would have overflowed, but in any event they would have been well supplied to cover the long period of deficient flow from July 27 to December 12, which followed.

The premises on which the foregoing computations, statements, and conclusions are based are approximate, yet they are sufficiently close to the truth to render the conclusions quite as safe as though the base data were more nearly perfect.

The construction of reservoirs on the upland tributaries of the Kanawha would effectually render the system of locks and dams unnecessary, but the reservoirs would cost far more than the dams, and if navigation on the Kanawha were the only issue the reservoir scheme would be impracticable. There are, however, three other important considerations—navigation in the Ohio, water power on the Kanawha, and the prevention of floods.

Navigation in the Ohio.—Until the system of locks and dams on the Ohio is completed, navigation of the Ohio channel during low-water seasons will be difficult. The operation of a reservoir system in the Kanawha alone would probably not render entirely unnecessary any of the locks and dams proposed for the Ohio above Louisville, but it would undoubtedly shorten the period of canalization; that is, the release of water from reservoirs would render it unnecessary to raise the dams as soon as they would be raised under present conditions, and the dams would, of course, be lowered again at an earlier period than otherwise. Any agency that will insure an open channel for the longest possible time will proportionately benefit navigation. It requires very little water from the Kanawha to provide temporary navigable stage in the Ohio under present conditions. On several occasions when coal barges have been moored at the mouth of the Kanawha, unable to go downstream because of low water, the system of movable dams in the Kanawha has been lowered and the water suddenly released into the Ohio. On the flood wave thus provided the fleet of coal barges has been transported to Cincinnati. It is apparent that little water is stored behind these movable dams and if the discharge thereof into the Ohio has been of such great benefit to navigation, it is evident that an extension of this scheme to cover all upland tributaries of the Ohio, so that the condition would be permanent, would be of much greater benefit.

Water power on the Kanawha.—The recorded minimum flow at Kanawha Falls is now about 1,000 second-feet. The ordinary low-water flow that would probably be used to define the limit of primary power installation is about twice that amount. It has been shown on preceding pages that the flow would never drop below 8,200 second-feet if the proposed system of reservoirs were constructed in the Greenbrier and New Basins. Now, it is the low-water flow that

defines the primary power available on any stream. Under modern power utilization the really valuable power is that which can be depended on 24 hours each day throughout the year. Therefore, any improvement that will increase the low-water flow may be considered a critical improvement of the highest value. The approximate effect in the increase of available power on the Kanawha above Lock No. 2, resulting from the construction of the reservoir system here proposed, is shown in the following table. It should be remembered that only the reservoirs on the New and Greenbrier are here considered, and that similar reservoirs on the Gauley and other tributaries would still further provide for increased flow.

Section of river.	Length.	Mean drainage area.	Minimum discharge.	Ninety-five per cent total fall.	Minimum horsepower, 80 per cent efficiency.	New discharge.[1]	Corresponding horse power.	Gain from storage.	Per cent of increase.
	Miles.	*Sq. mi.*	*Sec.-ft.*	*Feet.*		*Sec.-ft.*		*H. P.*	
Great Kanawha River, from foot of Loup Creek Shoals to below junction with Gauley River	9	8,310	2,240	48	9,780	8,200	35,800	26,000	266
New River from above junction with Gauley River to 1,000-foot contour	19	6,780	1,830	333	55,400	7,790	236,000	181,000	326
New River from 1,000-foot contour to 1,200-foot contour	24	6,560	1,770	190	30,600	7,730	134,000	103,000	336
New River from 1,200-foot contour to below junction with Greenbrier River	20	6,300	1,700	173	26,800	7,660	120,000	93,200	348
New River from above junction with Greenbrier River to below junction with Island Creek	20	4,220	1,400	73	9,300	3,850	25,600	16,300	175
New River from above junction with Island Creek to below junction Wolf Creek	17	3,750	1,280	69	8,080	3,730	23,400	15,400	192
New River from above junction Wolf Creek to below junction Sinking Creek	19	3,240	1,140	89	9,230	3,590	29,100	19,900	215
New River from above junction Sinking Creek to head of Siffords Falls	8	2,920	1,050	52	4,960	3,500	16,600	11,600	234
	....	....	....	....	154,100	....	620,500	466,400	....

[1] New discharge = discharge from storage + inflow (between reservoirs and Kanawha Falls), such that a minimum of 8,200 second-feet will prevail at Kanawha Falls.

Floods.—The probable effect of the Greenbrier and the New River reservoir systems in increasing the flow of the Kanawha at Kanawha Falls has been indicated in previous pages. It is clear that as the water released to maintain that increased flow is stored flood water, there must be an equivalent effect in reducing the height of floods. It will be profitable to estimate approximately what reduction could be effected by the Greenbrier and New Reservoirs, and for this purpose the events that attended a few of the floods during the period of observation will be reviewed. It will be remembered that the reservoir sites on the Greenbrier were shown to have a capacity largely in excess of the year of maximum run-off. The capacity of those in New River Basin was adjusted to correspond with the mean run-off from a certain area. At each site, however, there could be provided ample excess storage capacity for flood run-off, even though the reservoirs were filled up to the level required for the needs of navigation

and power. To suit such a condition it would merely be necessary to hold in reserve the excess capacity for the storage of occasional floods, and subsequently draw down the reservoirs to the established level and have them ready to catch another flood. Probably such a course would not be necessary; further study would have to be made to determine this point. It is assured that ample storage facilities are available to hold all floods, and the matter of adapting them to meet the precise conditions can be adjusted in the future. The capacity of the storage sites on the Greenbrier above Alderson is sufficient to control the run-off from 91 per cent of that drainage basin; that on the New, above Radford, will control the run-off from 46 per cent of the drainage area. In discussing the several floods the discharge at Kanawha Falls and the amounts contributed respectively by the New and the Greenbrier are estimated; then, by reducing the latter according to the percentage of reservoir control, the flow that would have occurred at Kanawha Falls may be determined by subtraction. The facts for each flood are presented in the following table:

FLOOD OF MAR. 3-10, 1899.[1]

Flow at Kanawha Falls.	Flow at Radford.	Flow at Alderson.	Probable flow at Kanawha Falls with reservoirs in operation.
Second-feet.	*Second-feet.*	*Second-feet.*	*Second-feet.*
33,500	8,340	9,800	20,700
47,200	26,400	36,200	12,100
201,000	49,200	48,200	134,000
157,000	31,200	26,300	119,000
82,000	21,500	10,800	62,300
46,700	17,000	6,440	33,000
36,300	12,000	4,560	26,600
32,500	10,400	3,960	24,100

FLOOD OF MAR. 19-25, 1900.[2]

15,400	5,260	1,710	11,420
51,600	16,300	15,900	29,600
85,200	18,800	16,400	61,600
63,500	13,300	8,000	50,100
41,000	9,540	5,400	31,700
29,000	8,740	2,770	22,500
26,200	7,550	6,310	17,000

FLOOD OF APR. 18-28, 1901.[3]

26,700	6,770	5,160	18,900
24,000	6,000	4,440	17,200
51,000	5,260	12,800	36,900
193,000	92,200	19,300	133,000
93,000	53,500	11,000	58,400
58,300	22,400	7,480	41,200
110,000	19,200	6,570	95,200
61,300	13,300	5,280	50,400
54,000	12,000	4,560	44,300
43,000	11,200	3,960	34,200

[1] The crest of this flood would have been reduced from 30.5 feet on the gauge to 22.2 feet, or nearly one-third.
[2] The crest of this flood would have been reduced from 15.9 feet to 12.6 feet.
[3] The crest of this flood would have been reduced from 29.6 feet to 22 feet.

FLOOD OF MAY 21-JUNE 1, 1901.[1]

Flow at Kanawha Falls.	Flow at Radford.	Flow at Alderson.	Probable flow at Kanawha Falls with reservoirs in operation.
Second-feet.	*Second-feet.*	*Second-feet.*	*Second-feet.*
13,000	7,160	1,050	8,750
41,000	7,350	17,000	22,100
224,000	117,000	17,000	155,000
89,000	58,100	8,600	54,500
47,400	26,400	4,800	30,900
39,300	16,000	3,360	28,900
72,700	23,000	13,700	49,700
103,000	28,800	18,200	73,200
85,000	29,800	10,700	61,600
60,600	24,000	7,740	42,500
43,800	18,300	5,280	30,600
34,000	15,100	3,840	23,600

FLOOD OF FEB. 25-MAR. 6, 1902.[2]

96,000	26,400	14,900	70,300
71,000	28,800	17,000	42,300
75,000	13,300	10,800	59,100
187,000	57,100	28,800	134,000
99,000	57,100	30,000	45,400
57,700	26,400	12,500	34,200
38,400	17,800	8,300	22,700
31,500	12,500	5,400	20,800
26,700	12,500	3,960	17,350

FLOOD OF JAN. 22-27, 1906.[3]

11,300	3,900	2,160	7,640
122,000	20,600	1,860	111,000
138,000	30,800	22,400	103,500
66,000	15,600	20,200	40,400
40,000	13,300	8,110	26,500
28,800	10,400	5,330	19,200

FLOOD OF JAN. 11-15, 1908.[4]

12,800	9,140	1,570	7,170
28,000	9,140	1,480	22,400
110,000	38,400	23,200	71,200
70,000	27,800	22,800	36,500
39,500	10,400	11,000	24,700

FLOOD OF FEB. 12-19, 1908.[5]

12,000	6,380	1,570	7,640
32,000	23,500	4,000	17,600
64,000	24,400	13,900	40,100
78,600	27,500	41,100	28,600
140,000	32,800	46,700	82,400
84,500	25,800	10,700	62,900
44,000	13,800	6,680	31,700
27,300	9,540	4,500	18,800

[1] The crest of this flood would have been reduced from 33.3 feet to 24.9 feet.
[2] The crest of this flood would have been reduced from 28.9 feet to 22.2 feet.
[3] The crest of this flood would have been reduced from 22.8 feet to 18.3 feet.
[4] The crest of this flood would have been reduced from 19.3 feet to 14 feet.
[5] The crest of this flood would have been reduced from 23 feet to 15.5 feet.

CONCLUSION.

The foregoing statements are intended merely to add to the weight of evidence that storage reservoirs are of so great benefit in all lines of river utilization that it is unwise to contemplate or to plan river development without including in the appraisal of conditions all storage possibilities. Nor should the matter be considered from any single point of view. If by the operation of a system of reservoirs for navigation purposes it is found that the schedule of operation is not the best that might be adopted for power purposes, then will it be necessary to determine on the most productive schedule for the one or the other, or both, according to relative values. But the fact that the reservoir system does not apply with highest efficiency to all purposes does not necessarily condemn the system. The appraisal of values must be based on net values. If their aggregate exceeds the cost of the reservoirs, then will the system be feasible.

No cost estimates have been given in the discussion of the Chattahoochee and Kanawha Reservoirs. That is a matter for future investigation. For the present we have the assurance that the large number of reservoirs already built have in nearly all cases conferred benefits far greater than their cost; further, that the majority of reservoirs that have been studied in detail, though not actually built, have been found feasible. There is therefore furnished a higher degree of assurance of success than that which attends the inauguration of business enterprises into which the wise financier readily invests his money and that of his clients. Few, if any, present-day lines of business have as fair a financial history as that of water storage.

APPENDIX III.

EFFECT OF THE FEDERAL RESERVOIRS UPON THE FLOW OF MISSISSIPPI RIVER FOR NAVIGATION AND WATER-POWER DEVELOPMENT DURING THE LOW-WATER PERIOD OF 1910.

By ROBERT FOLLANSBEE, district engineer United States Geological Survey.

INTRODUCTION.

The year 1910 in Minnesota was excessively dry, the rainfall in many sections of the State being less than one-half the normal (27 inches is the mean for the State). The drought therefore afforded an excellent opportunity to study the effect of the Federal reservoir system, at a time when the system was most needed, on the flow of Mississippi River, both in the interest of navigation and water-power development.

During the summer and fall of 1910 the Mississippi reached a stage so low as to call forth the opinion that the reservoir system was more or less a failure. A study of the conditions, however, shows that although the river was not kept at normal stage for navigation, it would have been very much lower had the upper Mississippi been unregulated.

RESERVOIR SYSTEM.

For the benefit of those who are familiar with the capacities of the five units comprising the reservoir system built and maintained by the Federal Government, the following table has been compiled from the Annual Report of the Chief of Engineers, United States Army, for 1906:

Capacity of Mississippi reservoirs.

Reservoir.	Area water surface.		Draft.	Capacity.
	Low water.	High water.		
	Sq. miles.	*Sq. miles.*	*Feet.*	*Cubic feet.*
Winnibigoshish (including Cass Lake)	117	161.0	14.0	43,992,000,000
Leech Lake	173	234.0	5.7	33,094,300,000
Pokegama	24	25.0	7.5	5,260,000,000
Sandy Lake	8	16.5	9.4	3,157,900,000
Pine River	18	24.0	16.2	7,732,900,000
Total				93,237,100,000

As these reservoirs are maintained primarily in the interest of navigation, they are operated in the following manner: When the Weather Bureau gauge at St. Paul records a river stage below 3 feet during the navigation season, the reservoirs are operated in a manner intended to hold the water at that stage. That this effort was not wholly successful during 1910 is shown by the following record of gauge heights at St. Paul, compiled from the Weather Bureau records:

TABLE No. 1.—*Daily gauge height, in feet, of Mississippi River at St. Paul, Minn., for 1910.*

Day.	June.	July.	Aug.	Sept.	Oct.	Day.	June.	July.	Aug.	Sept.	Oct.
1	3.2	1.6	0.6	0.9	1.0	17	2.0	.9	.8	1.0	1.3
2	3.0	1.8	.6	.9	1.0	18	2.3	.8	.8	1.0	.9
3	3.0	1.5	.8	1.0	1.0	19	2.1	.8	.8	1.0	.8
4	3.2	1.3	.8	1.1	1.0	20	2.0	.7	.9	1.0	.8
5	3.0	1.4	.6	1.0	1.3	21	2.0	.6	1.0	1.0	.8
6	3.0	1.2	.6	.9	1.3	22	1.9	.6	.9	1.0	.8
7	3.0	.9	.7	.9	1.7	23	1.8	.6	1.0	.9	.8
8	3.0	.8	.7	1.0	1.8	24	1.6	1.1	.9	.9	.7
9	3.0	.8	.8	1.0	1.8	25	1.8	.7	.9	.9	.7
10	3.0	1.2	.7	1.0	1.7	26	1.8	.6	.9	.9	.8
11	3.0	.9	.6	1.0	1.6	27	1.8	.5	.9	.9	.6
12	2.8	.9	.6	.9	1.6	28	1.8	.5	.9	.9	.6
13	2.3	1.0	.7	1.0	1.5	29	1.7	.5	.8	.9	.5
14	2.7	.9	.7	.9	1.5	30	1.4	.8	.8	1.0	.5
15	2.5	.9	.7	.9	1.5	31	......	.8	.8	......	.3
16	2.3	1.0	.8	1.0	1.5						

The foregoing table shows that the operation of the reservoir system did not keep the river at the 3-foot stage. However, it is not the purpose of this article to show what the system failed to accomplish, but rather what it did accomplish.

DISCHARGE OF UPPER MISSISSIPPI RIVER.

Records of flow.—Daily records of the flow from the various reservoir units are compiled by the United States Engineer office at St. Paul, and daily records of flow at Anoka and St. Paul on the Mississippi and on each of the principal tributaries between the reservoirs and St. Paul are kept by the United States Geological Survey.

In order to determine the effect of the reservoirs on the flow of the Mississippi and to determine the agreement between the various records, the flow will be analyzed by showing its various sources. The unit taken in this analysis is the monthly mean flow in second-feet. The following method has been used to make the flow at the different gauging stations comparable: At the reservoirs the unit period is the calendar month. The three reservoir stations selected for comparison are the Mississippi above Sandy River, which represents the flow from Winnibigoshish, Leech, and Pokegama Reservoirs, and the records of Sandy and Pine Rivers, which represent the discharge from the two remaining units. As Sandy River enters within a mile of the Mississippi station, the same period (the calendar month) is used for comparison. This time unit is also adopted for the Pine River records, though to be strictly accurate, the corresponding period should be one day later, or from the second of the month to the first of the next month, inclusive.

As it takes the water from the reservoirs about eight days to reach Anoka, and 10 days to reach St. Paul, the monthly mean at Anoka embraces the period from the 8th of one month to the 7th of the following month, inclusive, and at St. Paul from the 10th to the 9th, inclusive. The monthly periods on the tributaries have been selected in a similar manner, to give as nearly as possible comparable quantities.

The following tables, showing discharge of the Mississippi River above Sandy River and of Sand and Pine Rivers, were compiled from the United States engineer office records and represent the flow from the reservoirs. The records for the Mississippi at Anoka and St. Paul and for Crow Wing, Sauk, Crow, Rum, and Minnesota Rivers were compiled from the records of the United States Geological Survey. Most of the Geological Survey stations are near the mouths of the tributaries; others are some distance upstream, but a considerable portion of the drainage area of the stream lies below the station and the monthly mean for the station has been increased by an amount representing uniform run-off per square mile. The monthly mean for the Rum River station was increased by one-third. For no other station was the increase more than 15 per cent.

The other tributaries whose discharge is shown are very much smaller. Their run-off has been estimated from the run-off per square mile of the neighboring streams whose flow was recorded.

TABLE No. 2.—*Sources of discharge of Mississippi River above Anoka, and comparison of records.*

River.	Drainage area.	Mean monthly run-off in second-feet.							
		Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Mississippi above Sandy River	4,510	2,610	2,440	2,120	2,180	2,700	2,640	1,920	1,150
Sandy River	424	346	178	8	0	0	0	2	21
Willow	455	319	168	86	46	36	55	82	50
Rice	327	229	121	62	33	26	42	59	35
Pine	452	654	647	573	153	77	72	205	70
Crow Wing	3,580	2,080	1,200	607	397	316	571	654	460
Platte	353	148	64	42	25	25	25	25	23
Little Rock	93	39	7	6	6	6	6	6	5
Sauk	821	228	79	72	40	48	69	46	30
Clearwater	183	77	24	18	10	10	12	13	11
Elk	670	295	168	87	50	40	40	40	33
Crow	2,590	412	235	112	69	65	56	72	85
Total above Anoka	14,558	7,437	5,331	3,793	3,009	3,349	3,588	3,124	1,973
Mississippi station at Anoka	17,100	7,490	5,620	3,930	3,290	3,450	3,660	3,450	2,400
Difference due to minor streams and discrepancies in records	....	67	289	147	281	101	72	326	427

Table 2 shows substantial agreement between the sum of the discharge of the principal streams above Anoka and the corresponding discharge indicated by the record of the Geological Survey station at Anoka. It should be noted that although the Mississippi and its tributaries above Anoka drain 17,100 square miles, only 14,558 square miles are represented by tributaries considered in the above comparison. The run-off from the remainder of the area was very small, owing to the smallness of the minor streams and the extreme drought. Thus the difference that represents the flow of these minor streams and the discrepancies in records are not unduly small for the large drainage area unaccounted for. It is probable that the Anoka rec-

ords for November are somewhat large owing to the backwater from ice during the latter half of the month. Also during that month the discharge of the reservoirs fell from 2,400 second-feet to about 700 feet, and although the change is usually noticed in about 8 days it is possible that the effect of this large reduction may have lagged more than usual, making the corresponding period at Anoka somewhat uncertain. During the remainder of the year under consideration the flow was so uniform that a lag of two or three days would not make any appreciable difference in the results.

TABLE No. 3.—*Source of discharge of Mississippi River between Anoka and St. Paul, and comparison of records.*

River.	Drainage area.	Mean monthly run-off in second-feet.							
		Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Mississippi at Anoka	17,100	7,490	5,620	3,930	3,290	3,450	3,660	3,450	2,400
Rum	1,550	691	389	213	124	115	112	111	107
Minnesota	16,600	3,020	2,140	1,190	565	348	300	288	300
Total above St. Paul	35,250	11,201	8,149	5,333	3,979	3,913	4,072	3,849	2,807
Mississippi station at St. Paul	35,700	12,100	8,250	5,290	3,810	3,950	4,240	4,030	2,850
Discrepancy	450	899	101	−43	−169	37	168	181	43
Percentage of discrepancy	....	7.4	1.2	0.8	4.4	0.9	4.0	4.5	1.5

Table 3 shows the sources of the additional discharge between Anoka and St. Paul. It will be noted that of the 35,700 square miles of drainage area above St. Paul, the run-off from all but 450 square miles is included in the flow of the Mississippi at Anoka and Rum and Minnesota Rivers. The discrepancies between the sum of these records and that of the St. Paul station are due partly to the run-off of the 450 square miles unrepresented, and if this were considered the discrepancies would be reduced to errors in the records, except for the months of June and July, when the difference would be somewhat increased. However, this minor run-off has been neglected in determining the percentage of error between the sum of the records above St. Paul and the record at the latter place. It is seen that the percentage of discrepancy of error is well within 5 per cent for each month except April, when it reached 7.4 per cent, and therefore the records may be considered reliable in discussing later the increase due to the operation of the reservoirs.

The effect of the reservoirs will be shown (1) on the increased stage of the Mississippi at St. Paul for navigation, and (2) on the increased flow of the upper river available for water-power development.

EFFECT ON NAVIGATION AT ST. PAUL.

Having shown the various sources of the discharge which passed St. Paul, and the substantial agreement of the records on which the data are based, the following table is presented to show the percentage of this flow which came from the reservoirs:

TABLE No. 4.—*Percentage of discharge at St. Paul contributed by the reservoir system.*

River.	Mean monthly run-off in second-feet.							
	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Mississippi above Sandy	2,610	2,440	2,120	2,180	2,700	2,640	1,920	1,150
Sandy River	346	178	8	0	0	0	2	21
Pine River	654	647	573	153	77	72	205	70
Total flow from reservoirs	3,610	3,265	2,701	2,333	2,777	2,712	2,127	1,241
Mississippi at St. Paul	12,100	8,250	5,290	3,810	3,950	4,240	4,030	2,850
Percentage of flow from reservoirs	21.6	39.6	51.1	61.2	70.3	64.0	52.8	43.5
Percentage of drainage areas	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1

The foregoing table indicates that although the drainage area covered by the three reservoir stations was only 15.1 per cent of the total drainage area above St. Paul, the percentage of flow at the latter place originating in the reservoirs ranged from 21.6 in April to 61.2, 70.3, 64, and 52.8 during the low-water season.

Natural flow from reservoired area.—To show the increasing flow due to the operation of the reservoirs it is necessary to determine as nearly as possible the natural flow had the reservoirs not been built. For this purpose there are available the run-off from other streams in the same section of the State and the rainfall records during 1910. The first point considered will be the relation of run-off to rainfall during 1910 of the various streams in the northern half of the State, where general conditions are comparable.

In the following table the column "Run-off, depth in inches" represents the entire flow for the year stored on the drainage area above the gauging stations, with the result that the area would be covered to the depth indicated. The column of "Precipitation on basin" is the mean of all the rainfall records above the point of measurement.

TABLE No. 5.—*Relation of run-off to rainfall during 1910.*

Gauging station.	Precipitation on basin.	Depth in inches.	Run-off in per cent of precipitation.
	Inches.		
Crow Wing and Pillager	15.48	3.55	22.9
Rum at Onamia	14.63	2.97	20.3
Kettle near Sandstone	15.00	3.78	25.2
Snake at Mora	14.00	2.82	20.2
Wild Rice at Twin Valley	12.83	2.60	20.2
Red Lake at Thief River Falls	13.30	3.05	22.9
Red Lake at Crookston	12.40	3.02	24.3
Clearwater at Red Lake Falls	12.80	2.57	20.0
Little Fork at Little Fork	18.80	3.81	20.3
Mean	....	....	21.8

Each of the streams considered lies in the timbered portion of the State (the same as the headwaters of the Mississippi) and drains more or less swamp land. The percentage of the run-off for the streams is remarkably uniform, ranging from 20 to 25.2 inches with a mean percentage of 21.8. The run-off for the Mississippi above Sandy River, which was the principal source of the reservoir supply, was

35.6. This amount, which so greatly exceeds the run-off percentage of the other rivers, shows the effect of using water stored from previous years.

From the foregoing, it is reasonable to assume that the run-off from the area controlled by the present reservoir system would have been from 20 to 25 per cent of the rainfall had the reservoirs not been built. Twenty-two per cent has been selected as the most probable value, and as the mean rainfall on the basin for 1910 was 16.25 inches, this represents the total run-off for 1910 as covering its drainage basin to a depth of 3.58 inches.

On account of the large lakes through which the Mississippi flows in its upper course and which would be there, though in somewhat diminished size, if the reservoirs had not been built, the natural monthly variation would have been different from those other streams which are not naturally controlled by large lakes. Fortunately, there are available 1910 records of flow of Red Lake and Ottertail Rivers in the northern part of the State, which are both naturally controlled by large lakes to such an extent as to be comparable to the upper Mississippi.

Table 6 shows the mean monthly flow of these two streams for the period from April to November, expressed in percentage for the total flow for the year.

TABLE NO. 6.—*Percentage of monthly discharge to total discharge during 1910.*

Rivers.	Drainage area.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
	Sq. mi.								
Red Lake River at Thief River Falls	3,450	24.0	15.0	8.5	4.6	3.3	3.0	2.6	2.0
Ottertail River near Fergus Falls	1,310	18.0	18.0	12.0	6.7	2.9	1.4	1.9	2.9
Mean		21.0	16.5	10.2	5.6	3.1	2.2	2.2	2.4

The comparative uniformity of the variation in flow from month to month is what would be expected from streams similarly situated and naturally controlled to the extent that these streams are. It is also safe to assume that the natural flow of the upper Mississippi would have varied from month to month in such a way as to follow closely the flow of the Red Lake and Ottertail Rivers. Accordingly, the mean values from the preceding table have been taken in computing the natural monthly discharge for the area controlled by the reservoirs.

The drainage areas of the three sources of reservoir supply are as follows: Mississippi above Sandy River, 4,510 square miles; Sandy River, 424 square miles; Pine River, 452 square miles; or a total of 5,386 square miles.

In computing the natural monthly mean flow, which is shown in Table 7, the mean monthly percentages of total run-off, as obtained in Table 6, have been used. These have been applied to the 3.58 inches of run-off for the entire year, obtaining the value depth in inches over the drainage area, which represents the entire flow for each month as being stored on the basin. These values have then been changed into mean run-off in second-feet per square mile of drainage area and, lastly, into run-off in second-feet from the entire

drainage area of 5,386 square miles. These last values represent the computed natural mean monthly flow from the areas controlled by the reservoir system and indicate the flow that would probably have taken place during 1910 had the reservoir system been lacking.

TABLE No. 7.—*Natural mean monthly discharge from areas controlled by reservoirs.*

Reservoir supplies.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Percentage of monthly to total discharge	21.0	16.5	10.2	5.6	3.1	2.2	2.2	2.4
Monthly flow depth in inches	0.752	0.591	0.365	0.200	0.110	0.079	0.079	0.086
Mean monthly flow in second-feet per square mile	0.674	0.513	0.327	0.174	0.096	0.071	0.069	0.077
Mean monthly flow from the entire drainage area of 5,386 square miles	3,630	2,763	1,761	937	517	382	372	415

We are now in a position to determine the increased flow due to the reservoirs. Table 6 shows the actual monthly flow from the reservoirs, which, combined with the natural flow, shows the effect of the system.

TABLE No. 8.—*Effect of reservoirs on monthly discharge.*

	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Actual flow	3,610	3,265	2,701	2,333	2,777	2,712	2,127	1,241
Natural flow	3,630	2,763	1,761	937	517	582	372	415
Effect of reservoirs	—20	502	940	1,396	2,260	2,130	1,755	826

Thus it is shown that the mean monthly discharge in second-feet was increased by the reservoirs from 502 in May to 2,260 in August and 2,330 in September. After that the effect was less marked as the flow from the reservoirs was gradually reduced.

Having determined the effect on the mean flow caused by the operation of the reservoir system, it is a simple matter to show what this effect was on the stage of the river at St. Paul which affected navigation.

If the flow of the upper river were affected by given amounts each month, the flow at St. Paul for the corresponding periods (which as explained previously were taken 10 days later) was affected by the same amounts. It then only remains to determine the mean monthly stage of the river at St. Paul to correspond to the natural monthly flow and compare this with the actual mean monthly stage, to show the effect of the reservoirs upon navigation at that point.

The following table has been compiled from Tables 3 and 8, and shows the increased stage at St. Paul:

TABLE No. 9.—*Increased stage at St. Paul due to reservoir system.*

	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov
Actual flow	12,100	8,250	5,290	3,810	3,950	4,240	4,030	2,850
Effect of storage	+20	—502	—940	—1,396	—2,260	—2,330	—1,755	—826
Natural flow	12,120	7,748	4,350	2,414	1,690	1,910	2,275	2,024

The United States Geological Survey, under the direction of the writer, has rated the Mississippi at St. Paul with reference to the datum of the Weather Bureau gauge, which is 0.50 foot lower than that of the United States engineer office at the same point. The portion of the rating table concerned in the discussion is given herewith:

TABLE No. 10.—*Rating table for Mississippi River at St. Paul, Minn., for 1910.*

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
−1.1	1,650	1.0	4,110	3.0	7,300
−1.0	1,750	1.1	4,240	3.1	7,500
− .9	1,860	1.2	4,370	3.2	7,700
− .8	1,970	1.3	4,510	3.3	7,910
− .7	2,080	1.4	4,650	3.4	8,120
− .6	2,190	1.5	4,790	3.5	8,340
− .5	2,300	1.6	4,940	3.6	8,560
− .4	2,410	1.7	5,090	3.7	8,790
− .3	2,520	1.8	5,240	3.8	9,030
− .2	2,640	1.9	5,400	3.9	9,270
− .1	2,760	2.0	5,560	4.0	9,520
.0	2,880	2.1	5,720	4.1	9,780
.1	3,000	2.2	5,880	4.2	10,050
.2	3,120	2.3	6,050	4.3	10,320
.3	3,240	2.4	6,220	4.4	10,600
.4	3,360	2.5	6,390	4.5	10,880
.5	3.480	2.6	6,560	4.6	11,170
.6	3,600	2.7	6,740	4.7	11,460
.7	3,720	2.8	6,920	4.8	11,750
.8	3,850	2.9	7,110	4.9	12,050
.9	3,980	....	....	5.0	12,350

From this rating table the corresponding stages for the actual and natural mean monthly flow have been compiled as follows:

TABLE No. 11.—*Difference in stage at St. Paul due to reservoirs.*

	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Actual stage	4.90	3.45	1.80	0.75	0.90	1.10	0.90	0.00
Natural stage	5.00	3.25	1.20	− .35	−1.10	− .80	− .45	− .70
	−0.10	0.20	0.60	1.10	2.00	1.90	1.35	.70

From the foregoing discussion it is evident that although the operation of the reservoirs did not keep the river at the 3-foot stage at St. Paul, it is prevented from falling to a stage from 0.6 foot to 2 feet lower during the navigation period, from June to October.

EFFECT ON WATER-POWER DEVELOPMENT.

The fact that the upper Mississippi has a considerable fall, which is utilized by dams at five points below the reservoirs, made the increased flow from the reservoirs of considerable importance to water-power development during 1910. In order to show the average increased horsepower at each dam, it is only necessary to consider the increased average monthly discharge (as computed previously) falling through the distance at each dam represented by the available head. The following table represents the additional available horsepower, realizing 80 per cent efficiency:

TABLE No. 11.—*Additional horsepower (80 per cent efficiency) available at existing dams on the Mississippi River.*

Dam.	Average head.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
	Feet.								
Brainerd	14.5	− 26	663	1,241	1,843	2,983	3,076	2,317	1,090
Little Falls	21.5	− 39	979	1,833	2,722	4,407	4,544	3,422	1,611
Sartell	15.0	− 27	683	1,278	1,899	3,074	3,169	2,387	1,123
St. Cloud	14.5	− 26	663	1,241	1,843	2,983	3,076	2,317	1,090
Minneapolis:									
Upper dam	42.0	− 76	1,918	3,591	5,333	8,633	8,901	6,704	3,155
Lower dam	18.0	− 33	823	1,542	2,289	3,706	3,821	2,878	1,355
Total	125.5	−227	5,729	10,726	15,929	25,786	26,587	20,025	9,424

Between the mouth of Pine River, the lowest source of reservoir water, and St. Paul, which is practically the head of navigation on the lower river, there is a total fall of 490 feet, of which approximately 130 feet have been developed, leaving 360 feet undeveloped. The effect of the reservoirs upon the potential energy of this undeveloped portion is given as follows:

	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Additional horsepower	650	1,640	30,700	45,600	73,900	76,200	57,400	27,000

As the reservoirs are maintained primarily in the interest of navigation, their full effect is obtained only during the summer months. Therefore, only that portion of the year has been considered in this article.

Appendix IV.

THE PRACTICABILITY OF STORAGE RESERVOIRS TO PREVENT FLOODS AND TO BENEFIT NAVIGATION ON THE OHIO AND OTHER RIVERS OF THE UNITED STATES.

By Col. W. H. Bixby, now brigadier general, Chief of Engineers, U. S. Army.

[Being a review prepared in January, 1908, of a discussion by M. O. Leighton, Chief Hydrographer, United States Geological Survey, presented November, 1907, and printed as part of the Inland Waterways Commission Report, 1908, pages 451–490, on "The Relation of Water Conservation to Flood Prevention and to Navigation in the Ohio River." Review originally printed as National Waterways Commission Document No. 14. Footnotes added in 1912.]

1. The article of Mr. Leighton is an exceedingly valuable addition to existing literature on the subject of the possible use of storage reservoirs for preventing floods and benefiting low-water navigation. It gives a great deal of valuable new information not available in former days, and even available at the present date of his report only because of the liberality of Congress in recent years in providing funds for extension of geographic surveys by the United States Geological Survey throughout the United States, and especially in the Eastern States, and for extension of the Weather Bureau service. Mr. Leighton states on the first page of his report that his paper will have served its purpose if it demonstrates that the use of storage reservoirs in the upper tributaries of the great rivers, for the purpose of preventing floods and of maintaining navigable depths in the lower parts of such rivers, has so many features of promise that it would be a grave mistake for anyone to recommend the permanent adoption of a governmental policy which did not recognize the possibilities of such reservoirs and which did not provide for a further and a more minute investigation of the same. Mr. Leighton's position may be stated briefly as follows:

First, that the proper and logical way to control a river is to control its water supply by the use of storage reservoirs, which will store the water during rainfall, thereby preventing floods in the lower river, and which will allow the gradual wastage of the stored water during dry seasons, thereby increasing the navigable depth of the river at its ordinary low-water stages; second, that it is improper and illogical to attempt the control of floods by first allowing the flood waters to enter the lower river and afterwards endeavoring to confine such waters within high and expensive levees, and that it is illogical and disproportionately expensive to attempt to secure extra depth of water during the dry season by dredging or contraction, or by the use of locks and dams, unless storage reservoirs are impracticable or prove to be inefficient; third, that the control of nearly all the rivers of the United States can readily be effected by the construction and

use of storage reservoirs; and, fourth, that while the first cost of the storage-reservoir system will be large, such cost can be distributed over a series of years in such way as to ultimately appear nominal or small compared with the enormous benefit to be derived from the consequent flood prevention and improvement of low-water navigation, and much more so when considering also the benefit from the use of the stored water for water power and for irrigation. Mr. Leighton illustrates his discussion by an application of the storage-reservoir system to the Ohio River basin, claiming or at least implying that it will on that river give better results than the slack-water system now in progress and should be substituted therefor.[1]

2. Mr. Leighton's proposition stated as above (in slightly different language from his own) is, as he admits, a very old one, its discussion having been carried on for more than a hundred years in Europe and Asia, and for about sixty years in the United States. The American engineers who have most prominently taken part in such discussions are Mr. Andrew Ellet, about 1850; Mr. W. Milnor Roberts in 1857; Maj. G. K. Warren, U. S. Engineers, about 1870; Maj. W. E. Merrill, about 1873; Maj. F. U. Farquhar, about 1875; Capt. Charles T. Allen, about 1880–81, and Capt. H. M. Chittenden, in 1898; the discussions of Mr. Ellet, Mr. Roberts, and Major Merrill applying to the Ohio River; those of Majors Warren and Farquhar and Captain Allen applying to the upper Mississippi; and those of Captain Chittenden applying to the upper Missouri.

3. All engineers, both foreign and American, with great unanimity, have apparently agreed that theoretically the storage-reservoir method is the only proper and logical method up to its limits; but the engineering fraternity has been greatly divided, and still is to-day, on the question of the practicability of the reservoir method when considered from a combined legal and financial point of view. As stated by Mr. Leighton, the report of Mr. W. Milnor Roberts in 1857 was against its practical adoption in the United States at that date; and, while some of his reasons are no longer as valid as when first enunciated, his final conclusion, so far as concerns the United States, has been generally upheld by civilian engineers, army engineers, and by the United States Congress. In Mr. Roberts's original report of April 21, 1870 (p. 6, H. Doc. No. 72, 41st Cong., 3d sess.), he stated practically that a constant reliable navigation was the great desideratum; that he believed such navigation could be effected by the liberal expenditure of money; and that the necessity for some radical improvement and the expediency of the same seemed to be generally conceded, provided it could be effected in a satisfactory manner on such a plan as would commend general confidence.

According to Mr. Leighton, Mr. Roberts made a further very sensible observation (which Mr. Leighton admits will apply with equal

[1] As is now evident and as is confirmed by Mr. Leighton's later statement, his article was an academic discussion intentionally disregarding the conditions, customs, and laws of the day when his article was written. If we could omit all consideration of cost, of present prices of land, labor, materials, and power rentals, of existing needs, customs, and legislation—in short, if we could carry out work to-day along lines not allowable to-day, but perhaps allowable at future dates, his propositions might be considered more favorably; but the United States engineers have felt in recent years that in the work specially assigned to them, they should confine themselves to such conservative and sure methods as lie within the reach of existing legislation and as have in view mainly the probable benefits to the present and the next generation, leaving all supplementary work to future generations, who may perhaps have other views and other demands upon their funds. As originally presented, his article appeared to urge an immediate radical change of practice and policy.

force to-day), namely, that the question is not merely one of dollars, but it is of the first consequence that the adopted plan shall satisfy the sober good sense of the country, and shall in the end be productive of the greatest benefit. Such limitations show the whole matter to rest practically on the single basis where it has rested for the past one hundred years, namely, practicability and not possibility. As above stated, every engineer has agreed as to the possibility and desirability, up to its limits, of the storage-reservoir system from a theoretical point of view; but up to the present time, because of limitations imposed by existing laws as to land ownership and riparian rights, because of the long time necessary to obtain practical results, because of the large cost of the work, because of the fact that the benefits to be secured would affect many parties and objects other than those directly related to navigation (to which at that time the federal appropriations solely applied), because of the doubt that the benefit to navigation alone would be in proportion to its cost to navigation, because it might not prove sufficient, because of the difficulty of persuading the general public and Congress to appropriate immediately the money necessary for the full completion of the storage-reservoir project, as well as because of many other minor reasons—because of all these our engineers have been influenced to favor and follow the other better-known method of river improvement, viz, the dredging, contracting, and canalizing of the river, knowing that this would show immediate local beneficial results and final permanent good results, and that such method had been tested and found useful by many years of actual experience.

4. The main point raised by Mr. Roberts (pp. 26, 29, 124, of his Apr. 21, 1870, report) was, that while he believed the reservoir plan to be theoretically practicable, he considered it at that date unattainable within the practicable limits of cost (being governed, of course, by his immediate surroundings as to funds and by the local conditions of his immediate time), reporting that any reservoir system, in order to secure 5 or 6 feet low-water depth in the Ohio River, would probably require at least 273 reservoirs (elsewhere stated as from 30 to 300), with dams of from 60 to 100 feet in height (very high for that day) at a first cost of at least \$60,000,000 (elsewhere stated as from 30 to 90 millions), with at least half a million dollars more every year thereafter for maintenance, irrespective of accidents and other extraordinary contingencies. Mr. Leighton now suggests the use of over 100 very large reservoirs, occupying from 1 to 3 per cent of all the land area drained by each tributary (1 to 3 acres of every 100), with dams varying from 30 feet to 250 feet in height, all at a first cost of \$125,000,000 and perhaps very much more.

5. There is apparently no question amongst engineers as to the advisability of storage reservoirs on all very large rivers, if (*a*) all or the greater part of the water can be conserved; (*b*) if the water flow in the river and the adjoining land on its banks can be obtained free of cost to the United States, or if the question of cost be of no account; (*c*) if time for construction be of no account; (*d*) if accidents to the dams during construction and operation be impossible; (*e*) if the water can be freely used for domestic, factory, and municipal supply, for power development, and land irrigation; and (*f*) if supreme control by the Federal Government is practicable; but it would be hardly possible to expect all these conditions to be fulfilled for many

years to come. The question is, therefore, not what is advisable irrespective of the above conditions, but only how the United States can get the best general results for each dollar of cost under conditions of existing laws and existing local surroundings.

6. Heretofore, all river improvement in the United States under federal appropriations has, by existing law, been tied down to questions of navigation alone, irrespective of bank protection, of flood prevention and protection, of water power, and of irrigation. The objection to the storage-reservoir method has not been due to lack of suggestions by the United States Engineer Corps so much as the fact that Congress, representing the general public, has been reluctant to enter upon an enterprise of such magnitude in cost and such great extension of federal powers as would result from extending river and harbor improvement so as to include the other improvements above mentioned.

7. Mr. Leighton's descriptions of the various Ohio River Valley basins and his subsequent computations as to resulting water levels during low water and during floods are an excellent and valuable compilation and calculation, and they bear every sign of being useful so far as he has attempted to carry them. They show plainly a much more favorable condition for storage reservoirs in the Ohio basin than has heretofore been exhibited by anyone else. Above all other things they show what an enormous amount of potential water power is still awaiting development in the Ohio River Valley. If the local state legislature could be made to fully comprehend the situation, it seems hardly possible to believe that they would not take the matter in hand and enact such legislation as would permit and encourage a thorough development of this power by either individuals, corporations, municipalities, or the State itself.

It seems almost a crime to allow this wealth to remain undeveloped. But under existing law it is difficult for the Federal Government to interfere and assume control until a very much greater public benefit can be proven than is already in sight. The Great Kanawha River basin offers exceptional advantages for such treatment. If the Federal Government could forcibly take charge of all water power in this basin without compensation therefor and extend its reservoirs over about one-fiftieth of the whole basin, and hold them until coal and oil become scarce, the power development would then undoubtedly more than pay for the navigation improvements, no matter how made; but the present methods are absolutely regular and certain in their results and less revolutionary. It is possible that the storage-reservoir system would also have proved successful; but it is also possible that without federal assumption of power development the storage-reservoir system would have proved in the end equally or more expensive and not as certain. In almost all engineering work it is always considered best judgment to allow a large coefficient of safety (to cover cost of accidents, unintentional ignorance, and carelessness in construction and operation), and such coefficient seems hardly allowed for by Mr. Leighton.

8. There is no doubt that by increasing the size, capacity, and number of the storage reservoirs it would be possible to secure sufficient storage to hold back floods. Mr. Leighton plans for enough to give good results; but he does what no one heretofore has considered within the limits of federal appropriations and public consent, viz,

to occupy an average of 1.8 per cent of the entire area of all the basins named by him, and in one case occupying over 3 per cent. If this large occupancy should prove popular, or even allowable and practicable, his plans will then merit much further approval than heretofore given by engineers.[1]

9. Mr. Leighton makes no special reference to the valuable information and discussions which have appeared from time to time in the Annual Reports of the Chief of Engineers since the days of the reports of Mr. Ellet and Mr. Roberts (except his references to Major Chittenden and the 1905 board).[2] While the reports of Mr. Ellet and Mr. Roberts were the first to start opposition in the United States to the reservoir system applied to river improvement, the United States Engineer Corps has steadily given credit to the good features of the reservoir system; has given a practical first trial at the headwaters of the Mississippi River; has considered its use on the tributaries to the Mississippi between St. Paul and Cairo; and has been ready to extend the use of such system so far as seemed practicable. The real position to-day of the civil engineers of the country would seem to be very decidedly in accord with the report of January, 1881, by an engineer board consisting of Col. Q. A. Gillmore, Maj. C. B. Comstock, Maj. C. R. Suter, Mr. B. M. Harrod, and others (printed originally as H. Doc. No. 95, 46th Cong., 2d sess., and reprinted on pp. 2747–2754, Annual Report, Chief of Engineers, 1881), this board having been convened to consider especially the recommendations of Capt. C. T. Allen as given in his reports and projects of 1880.

The report of the 1881 board, while practically indorsing the modified system of reservoirs now in use on the upper Mississippi, states a decided opinion—that, omitting the question of cost, the reservoir system is the only system which would insure permanency and at the same time develop to the utmost the capabilities of a stream for navigable purposes; but that in order to efficiently supersede the other methods of river improvement the reservoir system must be of sufficient magnitude to control a large proportion of the river discharge, the direct benefits of the reservoir system being somewhat doubtful with the lesser magnitude of the development; and this report, while outlining the benefits and disadvantages of the reservoir system, brings out in special prominence the facts that the benefit to be secured to navigation from any reservoir system is to be measured principally by the rapidity and effectiveness with which it improves channel depths during the transition stage between floods and subsequent low water (by cutting out new channels through newly formed high bars) and by the added draft (distance from water surface to river bottom on the bar) which it gives at dead low water, rather than by the mere addition to the height of the low-water surface; and that the good effect during the transition stage, and the extent of such good effect, is yet to be proved by actual trial.

10. A subsequent report by a board, headed by Col. T. L. Casey (late Chief of Engineers), under date of May 24, 1887 (see pp. 1681–1693, Annual Report, 1887), convened especially to consider the results produced by the Pokegama Reservoir—the only one finished

[1] It must be borne in mind, however, that each flood-producing tributary must be provided with its own reservoir, and that reservoirs in order to be effective must be located at points below the areas contributing the flood water, such locations not being always practicable.

[2] According to Mr. Leighton's later statements, this was due to the shortness of the time allowed him by the persons ordering his report.

at that date—confirms the views of the 1881 board report; and while showing that this Pokegama Reservoir was able to raise the low-water levels in the Mississippi River 5.2 feet at 2 miles below the reservoir, 3 feet at 167 miles (Aitken), 1.5 feet at 383 miles (St. Paul), and nothing at 413 miles (Lake Pepin), this board states its conclusions that reservoir systems in general are economically advantageous only in regions of country where land has low value and where the population is small (private industries being interfered with the more as population increases); that such systems are advantageous not to replace other known methods, but merely as adjuncts thereto; and that the existing methods should still be given precedence in 1887 on the Mississippi (as yielding quicker and better returns) until such existing methods should be fully developed.

11. A still more recent board, headed by Maj. H. M. Chittenden, under date of November 27, 1905 (pp. 1443–1474, Annual Report, Chief of Engineers, 1906), considering the actual operations and results of the five reservoirs then in operation, which controlled 21.5 per cent of all watersheds above Minneapolis, reported that while finding that the reservoir system on the upper Mississippi River was there giving good results, was being operated by sound methods, and was then indorsed by the community as a whole, the existing five reservoirs had not added much more than 1.5 feet to the low-water stage at St. Paul through the three months of low-water season (considerable less to the low-water draft), failed to show any appreciable effect at Lake Pepin, and were still vigorously opposed by the owners of land above the reservoir dams who wished the land drained for agricultural and manufacturing purposes.

12. Even though the original reasons given by Mr. Roberts are no longer of the same force as when used by him, his general argument remains practically unchanged to-day, the details having been modified by the changes which have occurred in the commercial, navigational, engineering, and social conditions of the country. Because of his reasons of 1870, Mr. Roberts gave up the storage system as impracticable at that date, and his views were indorsed by the United States Engineer Department. Although engineers of to-day are ready to enter upon much greater constructions than in 1870, and although Congress is now ready to make much more liberal appropriations than in 1870, there still seems very great doubt as to the advisability even to-day of substituting for existing methods the single method[1] of storage reservoir construction, in view of the cost, the time occupied in construction, the difficulty of coordinating the interests involved, the extension of federal control necessarily required, and such other results as necessarily follow from the same. Some of the good and bad features of the reservoir method are given below in fuller detail.

13. *Benefits of reservoir system.*—Theoretically, and to the United States as a whole, the reservoir system carries great benefits: (a) In prevention of floods and protection against the same; (b) in improvement of low-water navigation; (c) in development of water power for manufacturing purposes; (d) in supplying a useful liquid for drinking, washing, sanitary, and chemical purposes, and for irrigation of land; and (e) in developing fisheries. Some of these benefits go to the public

[1] Mr. Leighton has, since the publication of his original paper, stated that he did not intend therein to advocate the reservoir method as the only one.

and some to private parties; and some of them apply above the reservoir dams and others below. The division of benefits between the public and private parties makes difficult the proper division of the cost of the work between the parties interested; and the division of benefits above and below the dam makes difficult the proper division of the use of the water.

14. Flood protection and prevention is largely a local matter. In many cases damage from river overflow is due mainly to the improper occupation of overflowable land by private parties, who do so because such land is naturally cheap at time of purchase, because they are willing to gamble on the chances of overflow, and because they have great hopes that they will eventually be protected in some way at public expense either by the local community or by the Federal Government; and the proper treatment of such cases would seem to be the enactment of local laws to stop such future occupation until the local protection works are duly erected, rather than encouragement of such risks. In many other cases the overflow is largely due to the improper use of the river bed by private parties for the deposit of refuse and for the reclamation of land in private interests, thereby stopping the proper flow of the water courses, this being done without any respect for the consequent damage to other interests, and the proper treatment of such cases should be the enactment of proper local laws to stop further abuse. In both these cases actual intervention by the Federal Government is undesirable and only necessary in case that the local States are negligent of their own duties and of the public interests.

Except for the Mississippi River below Cairo, the cases of overflow in the United States which are strictly federal are usually the exception rather than the general rule, and, consequently, the construction and supervision (including their cost) of protection works should be treated as more local than federal. All exceptional cases, however, which can not be corrected by local laws seem very properly to come under federal control and then to be necessarily payable for at public expense.

15. The benefit to low-water navigation occurs mainly below the dams, the reservoirs, as a rule, being necessarily in the upper part of the river where the latter is likely to be unnavigable; and such benefit concerns the public in general more than private parties, and such benefit makes itself usually evident in the shape of reduced rates and increased capacity of general transportation and in the special control of railroad rates. The benefit to low-water navigation is not as great to the lower part of the river as it is to the upper part, and may be restricted to only a small portion of the river next the reservoir. Whether the benefit can actually be carried effectively over the entire length of the river in the manner indicated by Mr. Leighton for the Ohio is still unproved.

According to the latest reports on the upper Mississippi reservoirs (pp. 1465–1466, Annual Report, 1907) it has been found that such benefit, amounting at St. Paul to from 9 to 18 inches increased height of water stage (and less if measured in available draft of boats) for ninety days of the summer low-water season, affects only about 60 miles of the river from St. Paul down to the center of the Lake Pepin reach, and its effect below this reach is practically inappreciable.[1]

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[1] In the portions of the river where the added height of water has been secured, the public demand is still mainly for power development and but little for navigation.

16. The benefit from water-power development, under existing law and custom, goes almost entirely to private owners below the dams, and their interests are sometimes quite different from the interests of the general public, and are liable to lead to constant trouble. If the water power can be taken possession of by the Federal Government without payment, or even at reasonable payment for damage to riparian properties, the rent from the same may sometimes be safely figured to amount in a few years to more than the entire cost of the reservoir. If the Federal Government has to pay the riparian owner for the injury to his existing water power, the highest prices will undoubtedly be asked; on the other hand, if the United States rents the developed water power to adjoining property owners it is safe to assume that the public will expect the lowest possible rates, which will probably be much lower by the time the dams are finished than they are at present. The estimated benefit figured by Mr. Leighton ($20 per horsepower annual rentage) seems much higher than can be counted upon in the future, as to which more details will be given later. The Federal Government will probably be fortunate if it realizes $10, or even $5, per horsepower per year.[1]

17. The benefits from water supply and irrigation usually go to municipalities and private parties below the dams; and their interests will be almost entirely opposed and detrimental to those of navigation. On this account it will be exceedingly difficult to arrive at any reasonable arrangement of division of cost between the irrigation and navigation interests. The irrigation public will want the most water at the times when it is most needed by navigation, and they will want it at the lowest rates.

18. The benefits for fisheries will go largely to the public in general both above and below the dam. Under favorable circumstances it is estimated by the Illinois State Internal Improvement Commission that the fisheries may return to the general public a value of as much as from $10 to $20 per acre of water surface; but it will be so difficult to secure the return of any of this profit to the Federal Government that none of such revenues can be properly counted upon to assist in the cost of construction and maintenance of the reservoir system.

19. Major Chittenden, in his extensive and valuable report of 1898, shows quite clearly that the actual benefits coming simply from flood prevention and navigation improvement can hardly be expected in themselves alone to justify the construction of storage reservoirs. But where flood prevention by proper rainfall storage, can be combined with flood protection works the matter may become sufficiently public to demand state and sometimes federal control, and where it also is liable to greatly assist general navigation in the lower river it may properly authorize federal control alone; in which cases there ought to be some way by which the revenues and other benefits belonging to the newly created reservoirs and their water powers might legally be used to defray the cost of construction and operation of the whole improvement. But so far it has not been found practicable.

20. *Handling of reservoirs for flood prevention.*—Providing that weather can be forecasted with certainty and that the storage reservoir has no other object to perform than to store floods, and that

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[1] In some important localities the public is already demanding that the Federal Government sell its water power at even lower rates than $5.

there are no limitations as regards the size and number of reservoirs, the storage-reservoir system should, theoretically, be able to prevent all serious floods in the manner indicated by Mr. Leighton. But in order to always have sufficient water held back for the low-water season it is hardly probable that the reservoirs will uniformly be in condition to catch the results of a sudden storm; as for surety in such matters, the reservoir should be kept only three-fourths to one-fourth full during all the months subject to flood, which means nearly half of the year. When a heavy rainfall is expected and actually forecasted, the time will always be too short for drawing down the reservoir to any large extent. Quick run-offs of water into rivers immediately after heavy rain storms are to-day largely due to the existence of roads, gutters, sewers, drains, clearings, etc., which are now everywhere established by cities, towns, counties, and all intelligent farmers and landowners. This element of quick run-offs will increase rather than diminish during coming years. Some of it may be held back by a proper system of reforestry, but not much.

21. *Handling of reservoirs for low-water improvement.*—The impossibility of forecasting with certainty a coming wet or dry summer, and the length of time which it takes for water released from the reservoir to reach the lower river, make it necessary for the improvement of low-water navigation to commence water storage early in the wet season, to hold the reservoirs full until the dry season is actually in evidence, and then, after starting the low-water flow, to keep it fairly regular and well ahead of its demand. Until weather can be successfully predicted several months in advance, and until the discharge from the reservoirs can be controlled absolutely by the Federal Government, the best intentioned service of storage reservoirs on rivers like the Missouri might prove dangerous to the lower portions of the river by causing the storage discharge to reach such lower portions at times when the latter might be already full to overflowing.

22. On the upper Mississippi River it has been found that the progress downstream of released water was twenty-one days for the first 70 miles, and sixteen days for the rest of the distance down to St. Paul. On the Ohio River the crest of a heavy flood requires seven days for passage in the open river from Pittsburg to Louisville, where conditions are many times better than in the Mississippi River above St. Paul. In order that the water shall run off freely when released, the river must be straightened and its sides and bottom made comparatively smooth, and the increase of current thereby caused is not always advantageous. It is still somewhat doubtful whether the amount of water flow named by Mr. Leighton would in actual practice be sufficient to keep the river steadily up to the levels named by him during the low-water season, and, if so, whether the river bottom will not be raised by the formation of new permanent bars so as to make the gain in available draft much less than the gain in stage. On the upper Missouri, within the limits of North and South Dakota, while there is often 3.5 to 5 feet draft at dead low water, there is only a draft of 3 feet at a 5-foot stage of water, the crest of bars rising with rising water. On the Mississippi River, from St. Louis to Red River, where the natural unimproved depth over the bars is only about 4 feet, the rise of bar crests is about half the rise of the river, giving below St. Louis only 14 feet on the bars at a 20-foot stage above low water, so that the benefit to navigation is rather illusory.

23. On the Ohio River in the past, a few attempts have been made to use the stored-up water of the Kanawha River slack-water dams, to send a flood wave down the Ohio River and thereby to carry through from the mouth of the Kanawha River to Louisville the coal fleets which had accumulated in the Kanawha. So far as these particular coal fleets were concerned, the experiment was fairly successful, but it was found that the water ran off so much more rapidly than was expected, that unless each coal fleet could keep close to the crest of the artificial flood, it was caught by falling water and was stranded on the river bars. These few experiments were not continued, because of the numerous protests against the same made by the local raft and boat owners down the river, as under the unexpected rise their log tows might float out over the bank or strand on shoals, and boats which had been insecurely moored on the banks might float away by the unexpected rise, and property (deposited freights) unloaded on the river bank by steamers might be submerged before it could be taken away. Of course, much of this trouble could be obviated if there were an extensive telegraph and telephone and patrol service all along the river bank; but even then the irregular fluctuations due to any sudden release of water from pools or reservoirs, are undesirable.

On the upper Mississippi, where regularity of release of stored water is undoubtedly desirable, several different methods were tried; and eventually it was found best to hold back the water so far as practicable (allowing for the time judged necessary for released water to reach the point of its use) until the water stage in the lower river approached that desired to be preserved during the low-water season, and then to release at first a small amount of water, afterwards more, increasing the same as the river stages fell and diminishing the same as the river stages rose, with a view to keeping the stage in the lower river fairly constant at, or a little above, its desired minimum. Although such method as above stated has secured on the Mississippi a 9 inches to 18 inches increase of low-water stage (with less gain in draft) at St. Paul, and although it is hoped and expected that this can be held during nine years out of ten, the actual permanency is yet to be proved. It is quite possible that the volume of stored water in these reservoirs, available for use, may later be increased by dredging a lower outlet (canal or tunnel) to the reservoir, by which the reservoir may be drawn down to lower levels than heretofore. Where such arrangement is practicable, such method may often be more economical and useful than to attempt to get an equivalent extra storage by building higher dams and overflowing larger areas. But all this work is still more or less tentative and the proof of permanent good results must depend upon long actual practice. The extent of success possible, when dams shall be many times larger and many times more numerous than already built on the Mississippi, while undoubtedly greater than so far obtained, is still quite debatable.

24. The above brings out forcibly one fact, namely, that regularity of storage-reservoir flow must either depend upon or lead up to an extensive system (*a*) of measurements of rainfall, run-off, gauge heights, storage, and water release, at the reservoirs; and (*b*) measurements of gauge heights and currents, in the river below; and to an extensive system (*c*) of information service (including telegraphs,

telephones, and patrols) to the boating and landed interests in the river below. The proper development of these must necessarily take much time, and will require large appropriations for the first and each subsequent year.

25. *Cost of the reservoir system.*—The cost of reservoir construction and land damages will, of course, be very great, and Mr. Leighton apparently admits this by his estimate of $125,000,000 for the Ohio River.

26. Such a system is practicable in Russia or India (where it has already been extensively adopted) mainly because land is exceedingly cheap, and labor is equally cheap. Similar features made comparatively cheap the construction of the five existing upper Mississippi reservoirs in Minnesota; but the cost of these reservoirs would probably be very much greater if such constructions were to be duplicated, commencing to-day. The American public are already beginning to realize the prospective value of water power as well as of land, and are beginning to charge high for the same and to obtain high compensation for the same under condemnation suits. (For further details, see first paragraph under head of "Special objections" below.)

27. Moreover, Mr. Leighton bases his approximate estimate of cost of a reservoir system on the cubic contents of his reservoirs; but considering the much greater value of land in the Ohio Basin than in the localities where preceding reservoirs have been built, and considering the great height of his reservoir dams and the consequent expensiveness of the same, it would seem to be much more proper for him to base his figures on the acreage of reservoir site, and on the square of the height of his dams, than on the mere capacity of the reservoir itself.

28. Besides, occasional accidents must be expected and should be estimated for, and to-day the business public are accustomed to a capitalization of the cost of insurance just as much as of the cost of other operations, and to the addition of the same to the first cost of construction when determining the total final cost of new works, which, of course, has not been done in this case. (See further under "Special objections" below.)

29. Any person estimating to-day upon the cost of dams will find valuable information in condensed form in the extensive tables compiled by Morris Knowles and printed as an appendix to a discussion of floods and their prevention on the Ohio River in the printed proceedings of the Engineers' Society of Western Pennsylvania for July and October, 1907. These tables contain most of the information previously given by the 1895 Massachusetts State board of health reports, by the 1897–98 Annual Reports, Chief of Engineers, U. S. Army, by the 1899 edition of Wegmann, by the recent annual reports of the United States Reclamation Service, and by recent engineering journals.

30. The eventual cost of a satisfactory system will probably go very far beyond the $125,000,000 of Mr. Leighton's estimate, perhaps to ten or twenty times such amount.[1]

31. *Extent of area needed for reservoirs.*—If the reservoir system is to be a success it must be of great magnitude. Major Chittenden in his 1897 report (p. 2852, annual report, 1898) states that he con-

[1] Later investigations tend to confirm these predictions.

siders a storage reservoir as having capacity enough to prevent floods if it is large enough to store one-fourth of the annual rainfall. Mr. Leighton apparently does not differ very far from Major Chittenden in his estimate. At any rate, Mr. Leighton apparently recognizes the necessity for a system of considerable magnitude, for in his article he provides for the Ohio River over 100 reservoirs, whose area is approximately 1,700 square miles, storing the outflow from the river basins of 93,000 square miles, total area; so that his reservoirs (although many of them are of great depth) occupy, as above stated, on an average 1.8 acres out of every 100 acres of river basins of the tributaries containing the reservoirs, and in some cases, as on the Little Kanawha and Big Sandy, even as much as 3.4 acres out of every 100 acres on the river basins. Considering the opposition that is liable to arise from submerging such a large proportion of the farms, roadways, and perhaps occasional villages, the sanitary protests that may come from the repeated partial emptying of the same, to say nothing of the cost of the dams and the land itself and the sacrifice of mines and other undeveloped properties that may be submerged. It is quite doubtful if the United States is prepared, even at the present time, to go into such an extensive development.

32. *The time for construction of reservoir systems.*—As has been intimated above, one of the drawbacks to storage reservoirs is the fact that the first constructions give no very appreciable results, unless the reservoirs are of unusually great capacity. Even then the effect of the first one or two is rather disappointing; and the public will be very liable to lose enthusiasm long before the system is completed. On the upper Mississippi River the original project proposed 41 reservoirs, the proposition being first agitated about 1868; it was 1874 before Congress could make any appropriations for surveys, and by that time the number of reservoirs to be immediately built was cut down to seven. In 1908, forty years from the first movement, the actual reservoirs built number only five, and, as has been above shown, the result in the way of assistance to low-water navigation, while valuable, has only been to add about 1.5 feet to the previous low-water stage and less to the available draft. At the rate of forty years for construction of only five reservoirs on the upper Mississippi River, it might take fifty or one hundred years to get 100 reservoirs on the Ohio, even admitting full value for all reasonable gain in public sentiment due to the good results already obtained on the Mississippi.

33. *Value of water power.*—While the water power which may be developed by the surplus water of storage reservoirs will be, of course, quite valuable, Mr. Leighton's estimates on the same are considered as too optimistic, especially in his figuring on one-half of the water being available for economic development and being worth $20 per horsepower year.

34. The Engineering News in 1895 shows that on the old hydraulic tunnels at Niagara, N. Y., the water power was rented sometimes as low as $4 per horsepower year and that on the newer tunnels the rent varied all the way from $21 in small quantities down to $10 per horsepower year in large quantities.

35. The Engineering News in 1900 (p. 49) shows rates sometimes less than $4 per horsepower year at Manchester, N. H., and Lowell, Mass., and rates less than $8 per horsepower year at Bellows Falls

and Turners Falls, Mass., all in New England, where factories are numerous.

36. The Annual Report of the Chief of Engineers for 1906 (p. 1469) shows rates less than $6 per horsepower year at Minneapolis, Minn.

37. The Chicago Sanitary District Canal, while hoping for $20 per horsepower year, is already seeing that it will be fortunate if it secures an actual $12 on an average for the entire surplus power.

38. In the new canal which is now being proposed in Canada for heavy-draft boats from Lake Huron, via Georgian Bay and the Ottawa River, to Ottawa, on the lower St. Lawrence River (see Engineering News, Oct. 3, 1907, p. 370), Canada is figuring on receiving only $12 per horsepower year for its surplus water power.

39. While parties who can exercise a monopoly may properly expect high rates for their surplus water power, the Federal Government, as well as state governments, can not safely expect to receive anything more than the lowest rates given to other parties—perhaps even lower—and, in any case, rates that are close to actual cost. The general sentiment of the country is that a public business is to be conducted for the public benefit rather than for the purpose of making profits, and if the Federal Government takes up the business of furnishing water power to the people it must be prepared to place the matter on the same basis as the Post-Office Department, which is obliged to ignore any question of direct profit.

40. If power development for federal use is desirable, such power might in many cases be obtained in connection with slack-water or lock and dam improvements by using the existing pools unchanged (as has already been done to some extent on the Muskingum River) or by building its dams higher or by constructing feeder canals from existing pools to power houses at advantageous points below. This might have been done in past days, and might still be done to-day, at St. Paul, Des Moines, Louisville, the Kanawha River, Tennessee River, and various other places. In some recent cases by congressional authority private parties have been allowed to construct dams or erect power houses on federal dams in navigable rivers (for example, the Tennessee River, Ala., and Rock River, Ill.) under condition that they either provided locks or lock sites or furnished other compensation to the Federal Government to assist public navigation. Much more might probably be done in such direction with benefit to the general public.[1] But public sentiment and congressional action are not yet specially favorable thereto.

It is quite probable that the present general feeling of the country is voiced by the statement in the House of Representatives on February 6, 1907 (Congressional Record, 1907, p. 2411), to the effect that although a general statute might be framed that would give to the United States Government control of water power along navigable waterways, there is no existing authority allowing the acquisition of such water power; and even if acquired it would have to be paid for under condemnation proceedings; and that it is questionable whether the Federal Government at present desires to go into such an enterprise merely for its water power.

41. *Some special objections to the reservoir system.*—As above indicated, storage reservoirs usually benefit existing conditions below the

[1] The big dam across the Mississippi River at Keokuk (Ill.), rapids is a marked example of what can be done at favorable places.

reservoir dam and usually injure existing conditions above the dam, so that extensive compromises are necessary between the conflicting interests. The 1905 board on the Upper Mississippi River reservoirs found on this river at that date at least seven of these conflicting interests, all of which had to be harmonized. If the storage reservoir is to be used primarily for benefit to navigation, it will become necessary for the Federal Government to assume positive and complete control and to indemnify the injured parties for the majority of their claims.

42. The existence of a storage dam will cause the overflow of large areas of land, mainly above the dams during water storage and secondarily below the dams during water release; such overflow may seriously injure or totally destroy the river bottoms for farming purposes or for resident sites or for manufacturing sites, and such bottoms being usually of rich soil, will be naturally held as specially valuable; and such overflow may interfere seriously with highway travel during the high-water stages of every flood, causing long detours to such travel. The storage reservoir may also injure existing or potential power plants mainly above the reservoir dam by destroying either the waterflow (valuable for paper mills and other factories needing good water) or destroying the head of water, which might otherwise have been serviceable for local power plants; and may also seriously flood and ruin mines and other underground properties. Under the existing laws as regards riparian rights, the landowner in the majority of the States of the Union has heretofore enjoyed the undisputed right to all uses of the land so far as not overflowed under natural conditions of the waterflow, and similar right to the use of all water front along his property, and all underground and underriver properties.

A recent brief article on this subject in the November, 1907, issue of the American Political Science Review, by R. H. Hess, of the University of Wisconsin, upon "The passing of the doctrine of riparian rights" shows that this doctrine is at present undergoing considerable revision throughout the United States and must soon undergo still further revision; but at the same time this article shows quite clearly that until such doctrine shall have been legally modified by constitutional enactments of the various States, not only the individual States but also the Federal Government, must abide by existing laws. Under such circumstances the construction of storage reservoirs means that the individual States or the Federal Government must compensate the riparian owner for his loss either by payments in money or in water power, thereby either purchasing or renting the overflowed land or paying damages for the right to overflow them, the price being usually fixed by condemnation proceedings, owing to the extreme difficulty of reaching any equitable result by private arrangements.

A compensation by payment in either water or water power, while occasionally made in the past by the United States, has almost invariably been found to result in serious later troubles, so that in general it is found necessary in the end to buy outright all land subject to overflow and to buy all water flow and water power subject to injury. All this means not only great expense in money, but also long delays in time. Any payment in compensation by furnishing water flow or water power may be no serious inconvenience during

high-water stages, but is sure to become troublesome and costly during low-water stages, when navigation wants all the water which can be spared. Power companies which usually commence with having more water than they have use for, almost always eventually arrive at a stage of development where their demand for water exceeds the supply. As the power companies will then wish to use more water than the average of the season, they will then endeavor to use the water steadily and to their fullest capacity throughout the winter and at other times when navigation interests will wish to hold it back for storage, by which use the reservoir will be drawn down to its lowest point considerably before the low-water season arrives, the power company having arranged to supplement its own lack of water during the low-water season by the use of steam power, leaving the navigation interests short of water at the very time when they need it most. Such treatment of water pondage is already a matter of actual practice. The power companies are naturally looking for profits, and as soon as they find that they can get a higher return out of the whole year by this method they will use every endeavor to do so. Even with such a big reservoir as Lake Superior, the conflict, between water-power demands for water supply and navigation demands for water storage, is already a fact of record.

43. Where storage reservoirs are intended to prevent floods as well as to improve navigation at low-water stages, there is a further difficulty, viz, that, for the best prevention of floods the storage reservoir should be emptied as rapidly as practicable as soon as such heavy rainfall is well over, so as to have the reservoir empty at the time of the arrival of the next flood; whereas for the best interest of low-water navigation it is desirable to keep the reservoir entirely full until the commencement of the dry season, and perhaps one-fourth full for emergencies until the dry season is nearly ended.

44. Another serious objection to the storage reservoirs, is the great element of danger in case of any accident to the dam while full. While the loss to property from annual freshets on a river like the Ohio is enormous, it is small in comparison with the loss of life and property which might result from the bursting in either the Allegheny or Monongahela River of a single dam 100 to 250 feet high, the latter of which might contain as much as 20,000,000,000 cubic feet of water. Until the arrival of at least another generation of people, who shall have forgotten the horrors of the Johnstown flood, it is probable that Pittsburg and the other large cities on the upper Ohio River will protest vigorously against the construction of many large and high dams on the river above them.

45. In comparing reservoir systems with slack-water improvement of rivers, the reservoir system suffers a further disadvantage in that very little good result can be expected until the system is nearly complete, or until, on the Ohio River at least, $100,000,000 have been spent; whereas in slack-water improvement the construction of each dam gives an immediate local benefit of much magnitude. Reservoir dams are rarely located in regions where they can be directly useful to cities, factories, or general navigation; but slack-water dams across rivers are very often placed below large tributaries and below large cities, where they establish extensive and deep quiet-water harbors above each dam available at all ordinary river stages, and especially valuable to the large commercial centers near

them. On the Ohio River, although the present slack-water system provides for 6 to 9 feet depth of water, each of these slack-water dams establishes pools averaging 20 miles each in length whose lower half is from 14 to 17 feet deep. The river front along these pools, therefore, becomes immediately of great value to factories and commercial houses, and the value of land along each bank is immediately and greatly increased. For such reasons, on the upper Ohio, between Pittsburg and Beaver, where five dams have already been built, at a cost of about $5,000,000, the increase in value of the mere land on one side of the river due to the development of deep slack-water pools was much greater than the total cost of all five dams.

The same results are to be expected farther down the river at Wheeling, Parkersburg, Cincinnati, Evansville, and Paducah. The slack-water dams below the mouths of large tributaries are also valuable to the steamboat interests of both tributaries and of main river, because furnishing a place below the mouth of the tributary where the local towboat fleets can be assembled for downstream travel, or where these fleets can be broken up prior to going up the main river or up the tributary. Such harbors also make possible for about half the length of each pool the establishment of systems of permanent docks with vertical fronts, and they make unnecessary to a large extent the use of the former floating docks, which require to be constantly moved up or down the river banks as the water varies between high and low water stages.

46. While the reservoir system assists the down passage of boats by furnishing a comparatively clear channel for navigation at all times of the year, the greater current will delay the up passage of boats. For a round trip downstream and back again there is probably not very much difference between the total time necessary under a storage reservoir system and a system of slack-water improvement.

47. *Summary.*—Briefly stated, the main objections to the adoption of a storage reservoir system to replace existing systems of river improvement in the United States, as recommended by Mr. Leighton, are as follows:

48. The United States does not seem to be yet educated up to the point of the extensive appropriation of land and the great expenditures necessary for effective storage reservoir systems, nor to the federal ownership of power dams, nor has it yet legally modified the doctrine of riparian rights sufficiently to allow of taking possession of existing water powers without due compensation to the former owners. The day may come when the United States will feel prepared to start in upon such propositions; but until that time, the executive departments must be prepared to proceed slowly in all such directions.

49. The storage reservoir system alone will not produce valuable results until it is nearly one-half or two-thirds completed, which will take very many years; during which time the lack of immediate results will cause much dissatisfaction to the navigation interests, who need immediate benefits, and to the general public, who are paying for the work.

50. The army engineer board of 1881, and all subsequent civil engineering reports, appear to either admit or fail to disprove the necessity of considering a storage reservoir system as merely an adjunct to the other existing methods of river improvement rather

than as a system which will be complete in itself. Undoubtedly dredging, contraction works, and bank protection, and perhaps even a large proportion of the locks and dams now looked forward to, will be necessary even with a perfect storage reservoir system. The slack-water system, as applied to the Ohio River, has already proved to the general public its ability to do the work which it proposes to accomplish, and such improvement is now generally understood and accepted. It seems very inadvisable to abandon an already proven and generally approved method, in order to adopt another not positively proved successful and which may require another twenty years to be thoroughly understood and appreciated and which even then will only supplement and not entirely replace the existing system. The slack-water system of improvement for the Ohio River has now reached such a stage that its successful accomplishment could be arrived at at any time within not more than six to eight years from the date when the funds are provided; and the cost of the same, even at the highest estimates of to-day, will only be about two-thirds of the low estimates of Mr. Leighton for the storage reservoir system.

51. While details of the objections raised by W. Milnor Roberts in his report of 1870 have changed with the growth of the country and of navigation plant and interests, his general objection of 1870 and those of the engineer board of 1881 to the use of the storage-reservoir system as a replacement of other methods are still serious ones and will still be supported by the practical judgment of the general public.

52. At the same time the storage-reservoir system, theoretically and as viewed from all its aspects, has enormous possibilities and advantages for the public at large and should be looked forward to as a desirable supplement to existing constructions as soon as law and general public sentiment are ready for the same; and it might be exceedingly desirable, from this point of view, to encourage the establishment of at least a few large storage reservoirs in the Allegheny and Monongahela river basins as an adjunct to the existing slack-water system of the Ohio River, as already approved by Congress.

If these first few storage reservoirs prove acceptable to the community and receive the necessary authority and appropriations of Congress, their construction and operation can not in any way injure existing navigation, ought to assist very materially the other improvements now in progress, and will serve as a valuable object lesson to the general public and to the engineering profession. As, however, the local benefits which will come from such reservoirs on the Ohio River will be felt most extensively and mainly in the prevention of floods, the protection of river banks, the development of water powers, and the establishment of water supply for domestic and manufacturing uses in the State of Pennsylvania, it would seem as if public sentiment for the same should first be created inside of the State of Pennsylvania, and the cost of the same should be paid for mainly by state appropriations or by the local corporations and individuals most directly benefited. Meanwhile the navigation interests of the Ohio River and all the influence of the Ohio River Valley Association will protest vigorously against any step which shall delay in any way the rapid completion of the existing slack-water improvement of the Ohio River which they already are acquainted with and know to be possible of giving the results which they desire.

53. *Suggestions.*—If it is thought advisable to develop further the storage-reservoir system in the United States to assist navigation, then probably one of the best places for such further development would be on the Mississippi River, between St. Paul and St. Louis, by an extension of the existing upper Mississippi system in such way as to cover the tributaries of the Mississippi between St. Paul and St. Louis (in the manner outlined by the 1880–81 reports of Captain Allen), with a view to securing a greater low-water depth from St. Paul to Cairo. This would help existing work, and might give very useful results at reasonable cost.

54. Until the time comes when the Federal Government is prepared to assume full control of water powers on navigable rivers, it might possibly be well for the Federal Government to give long-term leases of all its river rights, except navigation, to private associations or corporations, one or more in each river basin, on the condition that each association shall assume all cost and other financial responsibility of construction and operation of its dams and pools, and that in addition it shall build a proper boat lock or at least furnish a lock site at each dam, and shall guarantee to navigation a definite minimum stage above each dam, and minimum flow past each dam, during each of the low-water months of each year, all free of cost to the United States. Wherever the existing law allows the Federal Government the right to condemn land and flowage, these rights might be turned over to the dam owner or lessee, so as to simplify his legal difficulties. Under such conditions, it might be possible for the dam owner or lessee to even pay the United States a low rental for each horsepower per year thereby obtained, and still make a reasonable profit on his investment.[1] Such an experiment might easily be tested in the upper Mississippi Valley below St. Paul. The result could hardly make the Mississippi River water flow any more irregular than at present, and would undoubtedly raise the water stage somewhat, and might increase the boat draft appreciably. The risk would be small compared with the possible gain.

CHICAGO, ILL., *January 11, 1908.*

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[1] Some of the above suggested features have already been provided for by the general dam act of June 23, 1910.

Appendix V.

FORESTS AND WATER IN THE LIGHT OF SCIENTIFIC INVESTIGATION.

By Raphael Zon, Chief of Silvics, United States Forest Service.

|| Forest reservations ([illegible] 22-2[illegible]) ✓
| Water-supply, [illegible] ✓

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Appendix V.

FORESTS AND WATER IN THE LIGHT OF SCIENTIFIC INVESTIGATION.

By Raphael Zon, Chief of Silvics, United States Forest Service.

Object of the Report.

Of all the direct influences of the forest the influence upon the supply of water in streams and upon the regularity of their flow is the most important in human economy. Yet so many are the factors which play related parts in this influence, so great is the difficulty of observing them with precision, and so wide the range of economic interests affected, that considerable divergence of opinion has arisen on the subject. This, however, if prompted by a sincere desire to reach the bottom of a complicated and vital problem, can only be productive of results of the highest scientific value.

There is, perhaps, no other problem facing the American people to-day which demands such care in the scientific accuracy of its data and conclusions as does the relation between forests and water. It is imperative, therefore, that no final conclusions be drawn in regard to this relation until ample, reliable, and critically revised evidence upon which to base them is available. A national policy which, though considering the direct value of forests as a source of timber, fails to take full account also of their influence upon erosion, the flow of streams, and climate, may easily endanger the well-being of the whole people.

This paper aims to bring together impartially all the well-established scientific facts in regard to the relation of forests to water supply. Such a critical statement of our present knowledge of this subject should be helpful in separating what is definitely known of this relation from that which still needs to be determined.

Methods of Determining the Influence of Forests upon Streamflow.

The influence of the forest on streamflow can be determined in two ways: (1) By actual measurements, continued for sufficient time, of the total discharge and of the high and low stages of rivers having drainage areas essentially similar in regard to precipitation, geologic formation, topography, and soil, but differing in the amount of forest cover, and (2) by determining, through the measurement of individual factors, the total amount of water available for streamflow.

The first method, since it deals directly with the measurement of water, may properly be called the hydrometric method; while the other, which deals chiefly with the physical and mechanical effects of the forest upon evaporation, run-off, etc., may be termed the physical method. The first method studies the final result of all the factors affecting streamflow as they are shown in the behavior of the stream. It is the most direct, and would be the most practical, provided all the conditions of the watersheds studied, except forest cover, were essentially similar. Since, however, such similarity between watersheds is seldom met with in nature, this method, which has frequently been employed by engineers, is particularly liable to error. Further, the existing hydrometrical data are incomplete, for the hydrographic method requires the nicest observations, extending over a considerable period of time. The defects of the method in this regard were well brought out at the International Milan Congress of Hydrographic Engineers of 1905, as shown in the summary of the papers presented there.

The ideal application of this method would consist in comparing the regimen of a stream flowing from a completely forested watershed with the regimen of the same stream after its forest cover has been removed. As a control area there ought to be another watershed, exactly similar in character, on which the forest cover remains unchanged while that on the one under experiment is being removed. To make such a comparison thorough and accurate, the topography, geological formation, and character of the soil of the two watersheds should be surveyed, and each watershed then equipped, at different elevations, with ordinary and self-registering rain gauges, as well as with instruments for measuring evaporation, wind velocity, level of ground water, and especially the flow of the stream during different seasons of the year. This would yield reliable information as to the influence of forest upon streamflow for regions having similar soil, climate, and character of forest. Such experiments, however, with the exception of one now being conducted at Emmenthal, Switzerland, by the Swiss experiment station, and one at Wagon Wheel Gap, Colo., by the Forest Service, in cooperation with the Weather Bureau, have never been made in any part of the world. The most common practice, especially with engineers, has been to compare the run-off from drainage areas in the same general region, of which one may have more forest cover than the other. If the comparisons were based on equally large numbers of stream gaugings and dependable meteorological records, and the drainage areas compared were similar in regard to topography and soil, the average results might assume some practical value. Unfortunately, however, reliable gaugings for a given stream too often can not be supplemented by reliable meteorological data for the same region. Therefore, while there is no end to the material gathered in this way, it is often contradictory, at best showing only tendencies, and failing to determine with any accuracy the nature and extent of the influence which the forest has upon streamflow.

The second method analyzes separately the influence of the forest upon each of the different factors affecting streamflow, and the final effect of the forest upon streamflow is deduced from the combined effect on all the factors. While less direct, this method lends

itself more readily to experimentation, and has been largely employed by foresters.

Since a large amount of reliable data concerning the influence of the forest upon the amount of precipitation over forested and unforested drainage areas upon evaporation, surface run-off, percolation, etc., has been obtained by this method, it will be discussed first.

PART I.—RESULTS BY THE PHYSICAL METHOD.

FORESTS AND CLIMATE.

The influence of forests upon climate has been a subject of investigation for a long time, and is not settled yet. Now and then this influence has been exaggerated, thus leading to the other extreme of denying it entirely. In discussing the subject, therefore, one has to be very careful in selecting facts and in drawing conclusions from them.

The physical and physiological processes which accompany any plant growth must necessarily reduce the temperature of the air, at least during the vegetative period. First, because the leaves evaporate water. Second, because the heat of the sun is consumed in this evaporation, and the plant can not become heated to the same extent as, for instance, a rock or soil without any vegetative cover. Similarly, the ground under plants can not become greatly heated on account of shading. Third, the surface from which heat radiates at night is much greater when vegetation is on the ground than when the ground is bare. The cooling effect on the air by crops has been experimentally proven. For every pound of dry substance produced it has been found that corn evaporates 233 pounds of water and turnips 910 pounds.

Under good cultivation an acre may produce about 7 tons of dry substance. If the evaporation of water be only 500 times more than the amount of dry substance produced, then an acre will evaporate during the vegetative period about 3,500 tons of water. This example shows the extent to which ordinary crops can contribute to the moisture content of the air and the cooling which accompanies this evaporation. Forests, being the most highly developed form of vegetable life, exert this influence in the greatest degree.

The first systematic observations upon the effect of forests on climate were made in Bavaria. The climatic influences first observed were those which are least changeable from year to year and which are fairly uniform over large areas, namely, the temperature and humidity of the air, evaporation, temperature of the soil, and percolation of the water into the ground.

TEMPERATURE OF THE AIR.

Table 1 gives the results of early observations upon the temperature of the air outside and inside the forest carried on in central Italy,[1] eastern France,[1] in the mountains of Alsace, Bavaria,[2] and eastern Prussia.[3] The stations inside and outside the forest were

[1] Woelkov, A. I. The climates of the world (in Russian). St. Petersburg, 1884.

[2] Ebermayer, E. Die physikalischen Einwirkung des Waldes auf Luft und Boden. Berlin, 1873.

[3] Muttrich, A. Jahresbericht uber due Beobacht ungsergebnisse der im Konigreich Preussen und in den Reichslanden eingerichteten forstlich-meteorologischen Stationen, 1875, 1876.

scarcely a mile apart. The differences between the temperature of the air outside and inside the forest are shown by plus and minus. Plus indicates that the temperature in the forest is higher; minus, lower than in the field.

TABLE 1.—*Temperature of air in the forest compared with that in the open.*

	Central Italy.	Eastern France.	Mountains of Alsace.	Bavaria.	Eastern Prussia.
February-April:	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
Average of daily maximum	....	−1.44	−1.98	−0.90	−1.26
Average of daily minimum	....	+1.44	+3.42	+ .36	+ .18
Mean temperature	....	....	+ .72	− .54	− .54
May-July:					
Average of daily maximum	−7.38	−5.76	−4.50	−3.96	−2.52
Average of daily minimum	+2.88	+2.16	+3.42	+1.98	+ .90
Mean temperature	−2.16	−1.8	− .54	−1.62	− .72
August-October:					
Average of daily maximum	−6.48	−4.68	−3.42	−5.76	−2.88
Average of daily minimum	+1.98	+2.34	+4.32	+2.88	+ .36
Mean temperature	−2.34	−1.08	− .36	−1.44	−1.26
November-January:					
Average of daily maximum	....	−1.62	+1.62	....	− .54
Average of daily minimum	....	+1.08	+3.06	+2.16	− .36
Mean temperature	....	− .18	+2.34	+1.08	− .36
Entire year:					
Average of daily maximum	....	−3.42	−2.26	−2.70	−1.8
Average of daily minimum	....	+1.8	+3.6	+1.8	+ .36
Mean temperature	....	− .72	+ .72	− .54	− .72

This table brings out clearly the moderating influence of the forest upon temperature of the air. In the forest the maximum temperature is always lower, and the minimum temperature higher, than outside. More recent observations extending over long periods in France, Germany, Austria, Switzerland, and other countries have confirmed the earlier results.

The yearly mean temperature at equal elevations and in the same locality has invariably been found to be less inside than outside a forest. In a level country this difference is about 0.9° F. It increases, however, with altitude, and at an elevation of about 3,000 feet is 1.8° F.

The monthly mean temperature is less in the forest than in the open for each month of the year, but the difference is greatest during the summer months, when it may reach 3.6° F., while in winter it does not often exceed 0.1° F.

The daily mean temperature shows the same difference, but to a greater degree. During the hottest days the air inside the forest was more than 5° F. cooler than that outside, while for the coldest days of the year the difference was only 1.8° F.

The temperature of the air within the forest is, therefore, not only lower, but also subject to less fluctuation than in the open.

It is in tropical and subtropical regions that the influence of the forest upon the temperature of the air is probably greatest. In northern British India, in latitude 24–27° N., the mean annual temperature for the year varies but little with latitude. In winter the rainfall is very scant, and in summer very abundant. Before the rainy season the valleys of northern India have a period of extreme hot weather and drought. On the whole, the temperature and the dryness are moderated by proximity to the sea.

The country along the Ganges, and in general to the west of the lower extension of Brahmaputra, is almost treeless, while in Assam, along the middle extension of Brahmaputra, there are large forests. A comparison of temperatures at these places, made by Woeikov,[1] and given in Table 2, shows clearly the influence of the forest upon the temperature and humidity of the air. Of the places named, Brahmaputra lies at 24° N., the others between 25° and 27° N. The arrangement is from west to east.

TABLE 2.—*Difference in temperature and humidity between treeless and forested regions, British India.*

Locality.	Distance from sea.	Mean temperature.				Absolute maximum temperature.	Relative humidity (per cent).			
		Apr.	May	June	July.		Apr.	May.	June.	July.
Treeless region:	*Miles.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*				
Lucknow	526	86.18	91.94	91.58	86.72	114.44	30	36	54	74
Benares	367	86.36	91.76	91.04	85.46	113.00	41	60	81	82
Patna	267	86.54	88.52	88.52	84.56	112.28	.....	.....	.....	.....
Berhampur	168	84.28	86.18	84.56	83.66	111.38	52	60	75	79
Forested region:										
Goalpara	265	77.36	78.62	80.42	81.86	95.18	66	77	85	84
Sibsagar	345	74.30	77.54	82.76	83.30	96.08	81	82	83	88

The figures in the table indicate that forests play a much greater part in moderating the temperature in the hot and dry months of April and May than does proximity to the sea. The same thing holds for the relative humidity, especially in Sibsagar, which is the center of the forested region. The most striking influence of the forest is the lowering of the absolute temperature maxima. Proximity to the sea has but little effect upon this, but as soon as the forest region is reached, the absolute maximum temperature is at once decreased by about 15° F. Especially striking is the difference in the average temperature in May between Benares and Goalpara. The distance between the two places is only 462 miles, the latitude about the same, and the intervening country level. Both are at considerable distances from the sea, yet the difference in the average temperatures for May is 13° F., or about 1° for every 35 miles. This difference in temperature Woeikov explains by the presence of forest in Goalpara.

Woeikov further cites observations in the basin of the Amazon River, which possesses the largest forest area in the world. The middle and upper extensions of the Amazon River are about 621 miles from the Atlantic Ocean and are separated from the Pacific Ocean by very high mountains. At such great distances from the ocean, and so close to the equator, one would naturally expect to find very high temperatures and great dryness. Yet there the average temperature of the warmest month and the absolute temperature maxima are not greater than at the sea, and even not as high as the temperatures often experienced in middle latitudes. This is shown in Table 3.

[1] Woeikov, A. I. The climates of the world (in Russian). St. Petersburg, 1884, p. 321.

TABLE 3.—*Temperature and relative humidity in Amazon River basin and at points on or nearer the coast.*

Locality.	Altitude.	Latitude.	Distance from Atlantic Ocean.	Temperature. Mean annual.	Temperature. Average for the warmest month.	Temperature. Absolute maximum.	Temperature. Annual mean relative humidity.
	Feet.		*Miles.*	° *F.*	° *F.*	° *F.*	*Per cent.*
Para	....	1½°	62	80.6	81.86	....	....
Manaos	121	3°	714	78.98	80.6	97.26	80
Iquitos	311	3½°	130	76.64	78.26	90.32	83
Pernambuco	11	8°	....	78.26	80.78	89.06	72
San Antonio on the Madeira	....	9°	1,087	78.8	80.6	....	....

Woeikov attributes this remarkably moderate temperature of the Amazon basin to the cooling effect of the forest, due to the enormous evaporation of water from the soil and plants in the tropics. He assumes that in tropical countries covered with luxuriant forest vegetation the rainfall is seldom less than about 60 inches a year. So thick usually is the mass of decayed leaf litter and fallen and half-rotted trees in the forest that most of the rainfall is absorbed by the soil, and only a small portion runs off from the surface. Even allowing one-third of the annual precipitation for surface run-off, there is still transpired by the plants and evaporated by the soil a layer of water about 40 inches high. About 35.5 cubic feet of water are given off from every 10.7 square feet, and in the evaporation of this amount of water 606,500 calories of heat are consumed. The cooling of the air due to this evaporation explains why, in the vast tropical forests, the temperature of the air never becomes as high as it is even in middle latitudes.

The evaporation of water from forests differs from evaporation from water surfaces in that, while forests are, during the day, continually using up heat by converting it into latent heat through transpiration, bodies of water are directly heated by the sun's rays, becoming, as it were, temperature reservoirs. Interior seas and lakes in the tropics are often heated considerably above 82°, and even 86° F., and increase the temperature of the lower air when it is cooler than the water.

The total area of the leaves is so great that at night they cool off quickly. When they have reached the dew-point temperature, vapor of the air condenses on their surface. A part of the water which has been transpired during the day is thus brought back to be transpired again next day. The forests may therefore be likened to a self-feeding boiler, the water from which is evaporated into the air at the expense of the heat of the sun and surrounding air.

TEMPERATURE OF THE SOIL.

Forests influence the temperature of the soil in almost the same way as they do that of the air. The differences in temperature outside and inside of the forest, however, as a comparison of Tables 3 and 4 will show, are greatest in the case of the soil.

This is readily explained by the fact that the temperatures of bodies of air near one another tend to become equalized by the pas-

sage of air currents. Moreover, the surface of the soil is heated directly by the sun, while the air receives its heat chiefly from the surface of the soil, so that the difference between the temperature of the soil in the forest, where the ground is at least partially protected from heat, and that outside of the forest, where no such protection exists, is especially pronounced. This difference is not limited to the surface of the soil, but is manifest at a considerable depth.

TABLE 4.—*Difference in soil temperatures inside and outside the forest.*

	February-April.		May-July.		August-October.		November-January.		Mean annual.	
	At surface.	At a depth of 35.5 inches.	At surface.	At a depth of 35.4 inches.	At surface.	At a depth of 35.4 inches.	At surface.	At a depth of 35.4 inches.	At surface.	At a depth of 35.4 inches.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
Mountains of Alsace.	−1.8	+0.90	−14.04	−5.04	10.26	−5.76	+0.54	−1.26	−6.30	−2.70
Bavaria	−3.24	−1.44	− 8.10	−7.02	− 4.68	−5.4	....	− .18	−3.96	−3.96
Do	−2.34	−1.08	− 8.28	−7.38	− 4.68	−5.4	+ .54	− .18	−3.78	−3.6
Eastern Prussia	−2.34	....	− 7.92	−6.48	− 4.14	−3.96	+2.34	+1.62	−2.88	−2.16

In winter soil temperatures of the forest and field differ but little. The temperature of the soil in the forest is even somewhat higher, especially where snow lies on the ground for several months, when the difference is considerable. In eastern Prussia, for instance, it amounts to almost 3.6° F. The fluctuations of soil temperature in the forest, therefore, are much smaller than in the field. The moderating influence of the forest upon the temperature of the surface of the soil becomes especially marked when the maximum and minimum temperatures for the entire year are compared. (Table 5.)

TABLE 5.—*Fluctuation of soil temperatures inside and outside the forest.*

	Outside the forest.			Inside the forest.		
	Maximum.	Minimum.	Fluctuation.	Maximum.	Minimum.	Fluctuation.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
Bavaria (6 stations)	84.02	12.92	71.10	71.24	18.14	53.10
Mountains of Alsace	86.00	23.00	63.00	63.32	27.68	35.64
Eastern Prussia (2 stations)	81.68	6.44	75.24	64.58	16.52	48.06

More recent observations upon the temperature of the soil inside and outside of the forest yielded results very similar to the earlier ones. These later results show that the forest soil is warmer in winter by 1.8° F. and cooler in summer by from 5.4° to 9° F. than soil without a forest cover, and that this holds true for a depth of as much as 4 feet. In the spring, and especially in the summer, the forest soil is cooler than that of open land. In the fall and winter, however, it is warmer, but the degree of difference is always less than in summer.

Observations in 1892 and 1893 at L'Adlisberg, near Zürich,[1] showed that under the complete cover of a young beech stand the average temperature of the soil from April 1 to November 1 was from 9° to 12.6° F. lower than in the open on level ground, and from 10.8° to 18° F. lower than on ground sloping toward the south, but otherwise almost identical. On August 24, 1894, the soil on an open southerly slope attained a temperature of 91.4° F. Under the forest, close by on the same slope, the temperature was only 63.3° F. A cover of young beeches thus produced a soil temperature lower by about 28.1° F. The temperatures were taken at a depth of 2 inches; at the surface the difference was still greater.

The influence which forest cover has upon the freezing of the ground was well brought out by 21 years' observations in Germany,[2] as shown in Table 6.

TABLE 6.—*Freezing of soil inside and outside the forest.*

Stations.	Altitude, nature of soil, and composition of forest.	Depth to which soil freezes.		Difference.	Depth of frost in forest soil in per cent of depth in the open.
		Outside the forest.	Within the forest.		
		Inches.	*Inches.*		*Per cent.*
Haguenau (Alsace)	Rhine Valley, 492 feet; gravelly sand mixed with humus; Scotch pine.	19.7	8.3	11.4	42
Eberswalde (near Berlin).	160 feet; sandy soil mixed with humus; Scotch pine.	27.6	18.5	9.1	67
Neunath (Lorraine)	Plateau, 164 feet; lime rock; beech	8.7	5.9	2.8	68
Melkerei (Alsace)	Moderate southeast slope, 3,114 feet (167 feet below summit of slope); decomposed granite; beech and fir.	17.7	13.0	4.7	73

Thus, the soil under the forest may remain soft when the ground in the open is frozen hard to some depth. If it does freeze it is to a depth of from one-half to less than three-fourths that in the open.

RELATIVE HUMIDITY.

In the summer the relative humidity of the air is higher in the forest than in the open; first, because the transpiration of water by the leaves appreciably increases the moisture content of the air within or near the forest; and, second, because the temperature of the air in the forest is lower, and therefore nearer its saturation point. This difference is usually between 4 and 10 per cent, but in some places may be as much as 12 per cent. In regions of heavy snow there is practically no difference in the relative humidity during the spring, when the snow melts. Table 7 shows the difference between the relative humidity of the air outside and inside the forest for different months of the year.

[1] Bühler, A. Beobachtungen an den forstlich-meteorologischen Stationen, 1892, 1893. (Mitteilungen der Schweizerischen Centralanstalt für das forstliche Versuchswesen, 1895, vol. 4, pp. 34, 94.)

[2] Schubert, J. Der jährliche Gang der Luft- und Boden-Temperature im Freien und in Waldungen. Berlin, 1900.

TABLE 7.—*Relative humidity inside and outside the forest.*

	February-April.		May-July.		August-October.		November-January.		Entire year.	
	Outside the forest.	Inside the forest.	Outside the forest.	Inside the forest.	Outside the forest.	Inside the forest.	Outside the forest.	Inside the forest.	Outside the forest.	Inside the forest.
Mountains of Alsace.	80	85	68	75	78	84	85	89	77	84
Bavaria.............	80	84	70	80	78	85	87	90	79	85
Eastern Prussia.....	84	85	64	68	76	81	90	92	78	82

PRECIPITATION.

The water which reaches the ground and becomes available for vegetation and streamflow comes from two chief sources—first, rain, snow, hail, etc., which form in the upper strata of the air; and, second, dew, hoarfrost, and similar condensations of the air moisture which form on the surfaces of foliage, branches, and trunks, and also on the surface and in the interior of the soil when these are colder than the surrounding air.

EFFECT UPON LOCAL PRECIPITATION.

Observations upon the influence of forests on local precipitations began as early as the middle of the last century, but systematic observations did not start until the second half of the sixties (Bavaria, France, and Switzerland), and in many places are still being carried on. In a few cases these observations do not show any essential difference in the amount of precipitation over forest and over open fields. Most of them, however, demonstrate beyond doubt that the amount of precipitation over forests[1] is greater.

This excess of precipitation over forested areas varies from a fraction of 1 per cent to 25 per cent. Such wide variation is due partly to differences of geographic situation, altitude, character of the forest, etc. At the forest experiment station at Nancy, 33 years' observations show an average excess of precipitation on forested areas

[1] Blodget, Lorin. Climatology of the United States. Phila., 1857; Lorenz-Liburnau, Josef Roman von. Resultate forstlich-meteorologischer Beobachtungen insbesondere in den jahren 1885–1887, pt. 1–2. Wein, 1890–1892. (Mittheilungen aus dem forstlichen Versuchswesen Österreichs, Heft. 12–13); Bühler, A. Beobachtungen an den forstlich-meteorologischen Stationen Adlisberg, etc., 1889–1897. (Schweizerische Centralanstalt für das forstliche Versuchswesen. Mittheilungen, 1891–1898, v. 1, pp. 201–282; v. 2, pp. 61–126; v. 4, pp. 34–173; v. 5, 22–190; v. 6, pp. 18–28); Bühler, A. Die Niederschläge im Walde. (Schweizerische Centralanstalt für das forstliche Versuchswesen. Mittheilungen, 1892, v. 2, pp. 127–160); Hamberg, H. E. De l'influence des forêts sur le climat de la Suède, pt. 4–5. Stockholm, 1896; Blanford, H. F. Influence of the Indian forests on the rainfall. (Asiatic society of Bengal. Journal, pt. 2, 1887, v. 56, pp. 1–15); Studnička, F. J. Grundzüge der Hyetographie des Königreichs Böhmen. (Archiv für naturwissenschaftliche Landesdurchforschungen von Böhmen, 1887, v. 6, No. 3); Fritsch, Karl. Zur Frage über den Einfluss des Waldes auf den Regen. (Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, 1867, v. 2, pp. 230–235); Krutzch, H. Ueber den Einfluss der Waldungen auf die Regenverhältnisse der gemässigten Zone. (Tharander forstliches Jahrbuch, 1855, v. 11, pp. 123–141); Fautrat, L. Observations météorologiques faites de 1874 à 1878. Paris, 1878; Ebermayer, E. W. Untersuchungs-Ergebnisse über die Menge und Vertheilung der Niederschläge in den Wäldern. (Forstlich-naturwissenschaftliche Zeitschrift, 1897, v. 6, pp. 283–301); Müttrich, A. Bericht über die Untersuchung der Einwirkung des Waldes auf die Menge der Niederschläge. Neudamm, 1903; Hann. Julius. Wald und Regen. (Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, 1867, v. 2, pp, 129–136); Kopezky, Richard. Wald und Niederschläge. (Centralblatt für das gesamte Forstwesen, May, 1899, v. 25, pp. 195–213, 243–253); Zacher, Gustav. Ueber den Causalnexus von Wald und Regen. (Oesterreichische Vierteljahresschrift für Forstwesen, 1890, v. 40, pp. 103–108); and others in Russian.

of 23 per cent, while Ebermayer in Germany, Bouvard at Moumal, and Blandford in India compute it as being 12 per cent. Some meteorologists are inclined to ascribe the difference in the amount of precipitation over forests and open fields to the imperfection of the rain gauges. Hellman's[1] experiments, for instance, showed that the ordinary rain gauge in a wind of medium velocity registers 19 per cent less of precipitation than actually falls. It is possible that rain gauges in the forest, being protected from wind, will catch more rain and therefore show a greater amount of precipitation than when placed in the open. That the greater amount of precipitation over forest areas as compared with open fields can not, however, be ascribed entirely to this, has been clearly brought out by Müttrich, who, during four years of careful observation with Hellman's improved rain gauges, found that the difference of precipitation in the forest and outside the forest still amounted to 6 per cent.

French observers are practically unanimous in recording a larger amount of precipitation over forests than over fields. This conclusion is the result of experiments carried on at the forest school at Nancy, in the forests of Haye, by Fautrat in the forest of Halatte (Oise), and by de Pons in the forest of Troncais (Allier). Most of those carried on in Germany, Austria, Russia, and India have forced similar conclusions.

Regular observations taken at Nancy for 33 years since 1866, at stations inside, on the edge of, and outside the forest, show that, without exception, more rain has fallen inside than outside the forest, and that during 8 or 10 years more rain fell on the edge of the forest than outside. If the amount of the rainfall at the center of the forest be designated as 100, then the amount of rainfall at the edge of the forest would be represented by 93.9 and the rainfall outside the forest by 76.7.

The difficulty of bringing out clearly the influence which forests have upon precipitation results from the fact that the bulk of the forests are in the mountains. Altitude, as is well known, has a definite relation to the amount of precipitation, and unless this influence is eliminated that of the forest can not be clearly determined. To neutralize this altitudinal influence Prof. R. Weber[2] has grouped (Table 8) precipitation data obtained during a period of 10 years (1876–1885) at Prussian forest stations situated at different altitudes, together with average figures obtained by Dr. van Bebber[3] from 192 ordinary weather stations within the respective regions at corresponding altitudes but outside the forest.

[1] Hellman, G. Resultate des Regenmessungs-Versuchsfeldes bei Berlin, 1885 bis 1891. (Meteoroligische Zeitschrift, 1892, v. 9, pp. 173–181.)

[2] Weber, R. Die Aufgaben der Forswirtschaft(inLorey's Handbuch der Forstwissenschaft, 1903, v. 1, pp. 1–102).

[3] Bebber, J. van. Die Regenverhältnisse Deutschlands. München, 1877.

TABLE 8.—*Precipitation within and outside of the forest at different altitudes.*

	Altitude (feet).					
	3-300	330-650	980-1,300	1,970-2,300	2,300-2 600	3,000-3,250
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Stations in the forest (R. Weber)	25.9	26.2	29.4	42.9	55.5	69.9
Ordinary stations (Dr. van Bebber)	25.5	22.9	27.4	36.0	38.6	37.9
Difference	.4	3.3	2.0	6.9	16.9	32.0
Per cent	1.25	14.2	7.3	19.0	43.7	84.2

This table shows that, while the rainfall at the forest stations situated in the plains of north Germany exceeds the average for such lands by only 0.4 of an inch, or 1.25 per cent, the excess at moderate altitudes of from 328 to 656 feet amounts to 14.2 per cent. At elevations between 1,970 and 2,300 feet the difference is increased to 19 per cent, between 2,300 and 2,600 feet to 43.7 per cent, and between 3,000 and 3,250 feet to 84.2 per cent. These figures seem to show that the influence of the forest upon precipitation increases with the increase in altitude. Therefore, while it is true that mountains affect precipitation, wooded mountains affect it to a still greater degree. On the other hand, it is not true, as it was for many years commonly believed to be, that the rainfall chart is practically identical with the contour chart. In reality the matter is not so simple.

Angot, in his "Régime des pluies de la peninsule iberique," published in the Annales du Bureau Meteorologique de France, 1893, brings out most strikingly the fact that denuded mountains do not always cause moisture-laden winds to precipitate their moisture. An examination of the monthly and annual mean precipitation during the months of June, July, and August shows it to have an entirely different character from that during the preceding months. In June the fall is from 1 to 2 inches in the northern part of the peninsula and less than 1 inch in the southern part. In July and August only from four-tenths to 1 inch falls in the north and less than four-tenths of an inch in the south. "These three months, therefore, are the driest months, yet," says Angot, "the wind generally blows from the sea during this period, but owing to the excessive heat of the soil the moisture-laden clouds, on arriving inland, are further heated and are therefore further than ever removed from the saturation point. In all this mountainous region, which covers the Provinces of Granada, Jeon, and Murcia, in spite of the proximity of the sea, in spite of the entire absence of mountain ranges to the west which might precipitate the moisture before it reaches here, in spite of the presence within the region of the high peaks, some having an elevation of from 6,500 to 16,400 feet, the rainfall during July and August does not exceed four-tenths of an inch. It is certain that if these mountain ranges, which stretch between Sierra Nevada and Sierra Segura, were wooded instead of being absolutely bare and dry, the precipitation in the southeast of Spain would be increased, and there would be no fear of the disastrous floods which at times occur in the basin of the River Segura."

Wooded mountains, therefore, increase precipitation to a much greater degree than denuded mountains. This effect is especially

marked during summer months, and as Fautrat's[1] observations show, the effect is greater over coniferous than over broadleaf forests. The greater effect of coniferous forests upon the amount of precipitation can not be due to transpiration, since coniferous forests, as is well known, transpire less than broadleaf forests. According to Henry[2] this greater concentration of vapor over coniferous forests must be due to the fact that the crown of conifers intercept a greater amount of precipitation and therefore return into the atmosphere larger quantities of water than broadleafed trees. Fautrat's observations in 1876 showed that while the soil under broadleaf forests received 16.7 inches, the soil under coniferous forests received only 11 inches. Therefore, 5.7 inches, or 20,608 cubic feet, per acre were retained by the crowns of the conifers and returned into the atmosphere. Similar results were obtained by him in 1877.

Dr. Paul Schreiber,[3] a noted meteorologist, after working up elaborate meteorological data for Saxony, came to the conclusion that in a region completely covered with forests the influence of the forest in increasing precipitation would be equal to elevating the region 650 feet. A comparison by Prof. R. Weber of the precipitation data for seven years at the French weather stations at Cinq Transchees and at Amance is shown in Table 9. The two stations lie on an oölitic plateau near Nancy at an elevation of 1,246 feet above the sea. That at Cinq Transchees is located on a pasture surrounded by large forest areas, while the one at Amance is in a region practically stripped of forest. The results are given for the four seasons of the year.

TABLE 9.—*Precipitation over forest pasture and in treeless region, France.*

	Spring.	Summer.	Fall.	Winter.	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Cinq Tranchees (forest station)	6.3	7.4	7.6	8.3	29.6
Amance (not in forest)	5.9	6.5	6.2	7.0	25.5
Difference	.4	.9	1.4	1.3	4.1

The greater excess of precipitation over the forest pasture during fall and winter when the clouds are very low is no doubt the result of condensation due chiefly to the mechanical obstruction offered to the moisture-leaden strata of air.

During the four-year period from 1874 to 1877, Fautrat and Sartiaux conducted experiments on precipitation in the 12,500-acre state forest of Halatte. The experiments were carried on in the space above the tops of trees; in one case 23 feet above a hardwood forest, and in another 10 feet above a coniferous forest, with similar observations in the open. The observations yielded the following results:

	Above tree tops.	In the open.	Difference.
	Inches.	*Inches.*	*Inches.*
Broadleaf	25.8	24.8	1.0
Coniferous	26.3	24.0	2.3

[1] Fautrat, L. Observations météorologiques faites due 1874 à 1878. Paris, 1878, p. 21.
[2] Henry, E. Sur le rôle de la forêt dans la circulation de l'eau à la surface des continents. Paris, 1902, p. 14.
[3] Schreiber, P. Die Einwirkung des Waldes auf Klima und Witterung. (Tharander forstliches Jahrbuch, 1899, v. 49, pp. 85–204.)

Dr. Müttrich[1] observed at the meteorological station at Lintzel in the Luneburg heath the influence which the planting of a forest in the open waste land has upon the amount of precipitation. Planting was begun in 1877. At that time the region was made up of cultivated land, 12 per cent; heath, 85 per cent; and forest, 3 per cent. After the planting was finished the proportion of forest land had been increased to 80 per cent, and that of heath and agricultural land reduced to 10 per cent each. Regular observations on the amount of precipitation were begun in 1882, and the figures for each year thereafter compared with those for five neighboring stations where conditions had, of course, remain unchanged. For the years 1882–1888, inclusive, the precipitation at Lintzel, expressed in per cent of the average for the five other stations, was 81.8, 86.3, 95.2, 99.8, 100.6, 103.7, and 103.9, respectively. As compared with that at any one of the other stations, in fact, the precipitation at Lintzel showed a steady increase for the seven-year period. This demonstration of the effect of forest cover upon local precipitation is particularly striking.

A most direct proof, however, of the effect of forests in increasing local precipitation is afforded by observations following forest planting in the steppes of southern Russia. Between 1845 and 1863 over 5,000 acres of forest were planted in an entirely open situation in the high steppes (prairies). About 1892 two meteorological stations were established for determining in a most accurate and thorough manner the climatic influence of the forest. One station was located on the open steppe and the other in the forest. At the first the average annual precipitation during the period between 1893 and 1897 was found to be 17.9 inches, while in the newly established forest it was 22.2 inches, or 23.9 per cent more, in spite of the fact that the station in the open was located somewhat higher than the one in the forest. In addition, eight parallel observations on precipitation in the open and in the forest, carried on elsewhere, showed that the influence of the forest upon the amount of precipitation was greatest at the time of heavy rains, but was also well marked during the dry periods of the year. Thus, while the amount of precipitation at stations in the open during the summer of 1895 was 8.3 inches, that at the forest stations was 9.7 inches, or 16.4 per cent greater. These observations tally with similar ones taken in 1894 and 1895 by J. Klingen in the open steppe and in the neighboring forest of Chrinovsky, in the Government of Voronej.

TABLE 10.—*Precipitation on the open steppe and in pine and oak forests.*

	Total for the year.		Total for the growing season.	
	1894	1895	1894	1895
	Inches.	*Inches.*	*Inches.*	*Inches.*
In the open steppe	13.9	14.1	12.0	7.6
In a pine forest	19.9	19.8	15.0	10.1
In an oak forest	21.3	20.7	13.9	10.3
Excess in pine forest over the open, actual	6.0	5.7	3.0	2.5
Excess in pine forest over the open ... per cent	43.0	40.0	25.0	32.0
Excess in oak forest over the open, actual	7.4	6.6	1.9	2.7
Excess in oak forest over the open ... per cent	53.0	46.0	16.0	36.0

[1] Müttrich, A. Ueber den Einfluss des Waldes auf die Grösse der atmosphärischen Neiderschläge. Zeitschrift für das gesamte Forstwesen, 1892, v. 24, pp. 27–42.)

The effect of forests upon precipitation, as shown from the data brought together by such meteorologists as Woeikov and Blanford, is even greater in tropical and subtropical climates than in temperate regions. Thus, for British India, Woeikov shows that the forest cover exerts a greater influence upon precipitation than does proximity to the ocean.

TABLE 11.—*Precipitation in forested and treeless regions, British India.*

Locality.	Distance from sea.	Precipitation.			
		April.	May.	June.	July.
Treeless region:	*Miles.*				
Lucknow	526	0.2	0.7	5.0	15.5
Benares	367	.2	.5	5.0	12.9
Patna	276	.4	1.0	6.0	10.9
Berhampur	168	2.2	3.9	9.5	10.1
Forested region:					
Goalpara	265	5.8	13.0	26.3	19.6
Sibsagar	345	10.2	12.0	15.5	15.9

H. F. Blanford, meteorologist to the Government of British India, regards Woiekov's statement as too sweeping, but admits that the forest is one of the elements which contributes to the amount of precipitation over Assam Valley. He furnishes a very striking evidence of the effect of forest protection upon increase in precipitation. In part of the central Provinces of British India a forest area of about 600,000 acres has been protected for a number of years (since 1875) from fire. As a result there appeared, under the thin stands of trees, a dense young growth. Complete precipitation records were kept at seven stations from 1865 or 1867 up to the present time. A comparison between the precipitation before 1875 and after 1875 (Table 12) shows a marked increase in the latter period for the same area.[1]

TABLE 12.—*Precipitation over protected forest area, British India.*

Weather stations within the protected region.	Observations begun.	Mean annual precipitation.		
		Before 1875.	After 1875.	Difference.
		Inches.	*Inches.*	*Inches.*
Badnur	1867	39.83	47.83	+ 8.00
Chhindwara	1865	41.43	48.48	+ 7.05
Seoni	1865	52.07	54.76	+ 2.69
Mandla	1867	53.58	56.32	+ 2.74
Burha	1867	64.51	71.65	+ 7.14
Bilaspur	1865	41.85	54.81	+12.96
Raipur	1866	51.59	54.41	+ 2.82
Average		49.27	55.47	+ 6.20

Practically all observations, then, tend to show that there is an increase in the total amount of precipitation over wooded areas as compared with that over barren or deforested ones. One reason for this is undoubtedly the tendency of moisture-bearing currents to precipitate their moisture more readily above or near the forests than

[1] Brandis, D. Regen and Wald in Indien. (Meteorologische Zeitschrift 1887, v. 4, p. 375.)

over bare or cultivated fields at the same elevation, due to the dampening and chilling effect of the forest upon the atmosphere, which induces a greater condensation of the water vapor.

That the air over forests contains a much larger amount of moisture than that over bare or cultivated fields is to-day a proven fact, based both on actual observations in the upper air strata and determinations of the quantities of water evaporated by the forest. The latest experiments by Russian agronomists and foresters, corroborated by similar observations in France and Germany, have shown conclusively that in level or slightly hilly regions (where the stratification of the rock is horizontal and the ground waters are stagnant, as, for example, in the steppes of Russia or the landes of Gascony) the forest has a desiccating effect upon the ground, causing the water table to be lower under forest than in adjoining open fields. Prof. Henry, in his recent investigations upon the effect of forests upon ground waters in level country, found that the minimum depression of the water table produced by the transpiration of forest trees in the Mondon forest near Luneville, France, amounts to 11.8 inches. With a porosity of the soil strata ranging between 45 and 55 per cent, such depression would correspond to a rainfall of 5.9 inches, which amounts to 21.443 cubic feet per acre.

This amount of water given off by the forest into the air obviously contributes greatly to the moisture content of the atmosphere above the forest. Dr. Franz R. von Höhnel,[1] of the Austrian forest experiment station at Mariabrunn, after observations carried on for a period of three years (1878–1880) upon the amount of water transpired by forests, found that one acre of oak forest, 115 years old, absorbed in one day from 2,227 to 2,672 gallons of water per acre, which corresponds to a rainfall of from 0.09 to 0.115 per day, or 2.9 to 3.9 per month. Taking the period of vegetation as five months, the absorption of water would be 158,895 cubic feet, which represents a rainfall for this period of 17.7 inches. This amount of water is given off through transpiration from the leaves and does not include the physical evaporation from the surface of the twigs, branches, and leaves. These figures, while only approximate, give an idea of the enormous quantities of water given off by forests into the air, which has justly given them the name of the "oceans of the continent."

As a matter of fact, small clouds are frequently observed hanging persistently over forested areas in the presence of a fairly strong wind. If all the moisture given off by the forest could be made visible as a fog, heavily forested areas would appear enveloped by a damp mist, more dense over coniferous than over broadleaf forests.

That the vertical influence of the forest extends to a height far greater than 100 or 200 feet has been proven by observations taken during balloon ascensions. Thus, Renard, commander of engineers, and subdirector of the Central Military Balloonist Institute of France, states that the effect of the forest upon the temperature of the upper strata of air has been repeatedly felt during ascensions at an elevation of nearly 5,000 feet over the forest of Orleans, which has an area of 75,000 acres. This influence is scarcely felt over field crops, and it is obvious that the difference can not be due to the

[1] Höhnel, F. R. von. Ueber die Transpirationsgrössen der forstlichen Holzgewächse. (Mitteilungen aus dem forstlichen Versuchswesen Oesterreichs, 1881, v. 2, pp. 47–90, 275–296.)

greater height of the trees, which at best reach but a little over 100 feet on an average. It can be accounted for only by the greater amount of water given off by the forest and the lower temperature above it.

The condensation of vapor on the surface of leaves in the form of dew, hoarfrost, etc., in northern latitudes, according to C. E. Ney,[1] is from 0.4 to 0.8 inches a year. It is much more in southern latitudes, especially in tropical forests. The condensing capacity of many tropical forests, because of the extreme dampness of the air within them, is so great that during every clear and still night drops of dew fall continuously from the leaves as in rain. (This is also the case in the redwood belt on the Pacific coast.) Thus part of the moisture which is evaporated from the leaves during the day is condensed during the night, and the dews in the forest in all latitudes are so heavy that they dampen the soil under the leaves.

Condensation formed within the soil may be omitted from this discussion, judging from the results of local observations over limited areas, since there seems to be no difference in this respect between open field and forest.

Another reason for greater precipitation over forests may be the mechanical action of the trees themselves. When a cloud in the mountains passes through a forest, the branches and the leaves of the trees retard its movement. It comes, therefore, into a state when it can no longer retain its moisture in suspension, just as a river carrying sediment deposits part of it as soon as the rapidity of its flow is diminished. The moisture from such clouds is intercepted by the forest in the form of mist or drops of dew or crystals of hoarfrost on the branches and foliage of the trees.

The mechanical action of the forest is especially important in the case of snow. The influence of forests upon the amount of snow has been especially studied in Russia, where in some places more than 30 per cent of all the precipitation is in that form. During heavy storms the forests not only catch more snow than do large open fields, from which it is blown away, but they prevent it drifting. There is always more snow deposited within the forest than in nonforested areas, except in depressions and protected places where snow accumulates. In regions where the snowfall is heavy the amount of snow that accumulates in the forest, and especially in small openings within the forest, is often so great that gauges located even under the crowns of trees contain more snow than those located in large open places, in spite of the fact that snow is very readily retained by the branches, especially in coniferous forests, and that part of the snow thus retained by the trees gets into the rain gauges only at the time of thawing, and therefore can not be accurately recorded. The results of many years of observations in Russia upon the accumulation of snow in the forest and outside of it have conclusively shown that young forests, deciduous forests, and small openings within the forest collect nearly twice as much snow as open fields.

After all, it really matters very little for the final result whether the increased precipitation over the forest is due to its influence upon the condensation of vapor in the air or to the mechanical action of its branches and leaves. The fact remains that forests receive more precipitation than open fields.

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[1] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

PRECIPITATION OVER CONTINENTS.

The effect of the forest upon local precipitation, however, is insignificant as compared with its effects upon the precipitation over the interior of continents.

The moisture given off into the atmosphere by forests is carried great distances over the country or out to sea before it appears as rain; yet, owing to the enormous quantities of water given off by the forest, the amount of moisture in the air, and consequently the chance for rain, is increased. So widely distributed is this influence, however, that even the most exact observations could never determine its extent. The great drawback to local observations, on the other hand, is that the neighboring open areas, the climate of which is compared with that of the forest, are themselves under the influence of the forest.

Prof. Lorentz Liburnau, at the end of his book on Forest, Climate, and Water, remarks that his data and conclusions apply only to the influence which the forest exerts while it exists, but do not extend to conditions which may arise from its complete destruction. "If, for instance, according to our observations in the Carpathian foothills, it appears that the influence of the forest upon the neighboring country is only insignificant, this does not indicate that a complete destruction of all the existing forests will produce here also only insignificant climatic changes. Very likely, if the forest were completely destroyed, the difference would be much greater than that which now exists between the climate of the forest and its neighboring areas."

Source of atmospheric moisture over the land.—While definite observations to show the relation between the forest and the climate of continents are still lacking, there are many theoretical considerations which strongly point to a distinct influence of the forest, especially upon the climate of large continents of a level character.

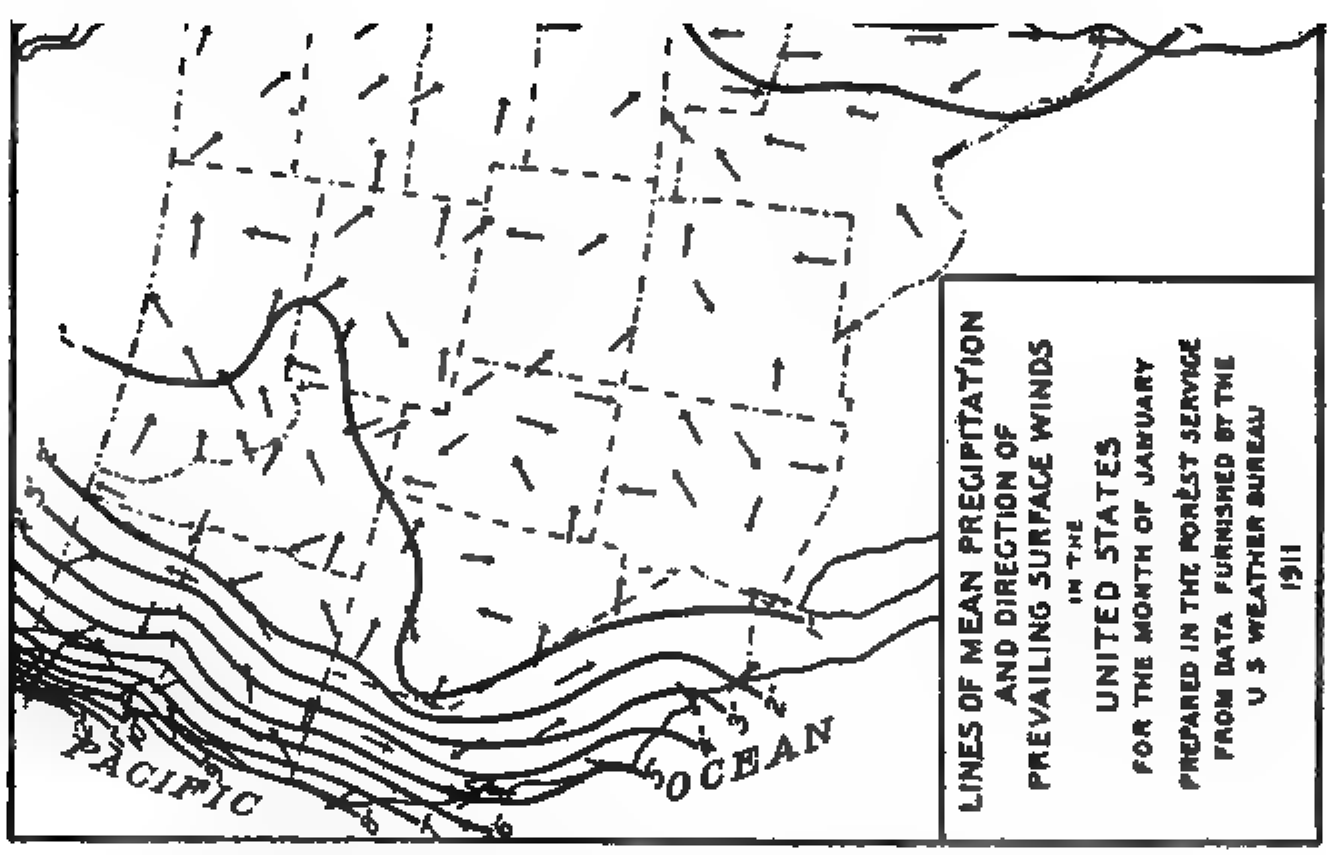
The accompanying maps, on which the direction of the prevailing winds is indicated by arrows and the mean precipitation by lines, one typical of the summer period and the other of the winter, show a most intimate relation between the prevailing winds and precipitation in the eastern half of the United States. A high meteorological authority in this country states that the "precipitation in the eastern half of the United States is from the aqueous vapor that is raised up from the vast waters to the south and southeast of the continent," and that "the supply is inexhaustible."[1]

If by this is meant that the precipitation over the eastern part of the United States is derived entirely from evaporation from the Gulf of Mexico and the Atlantic Ocean, the statement is not entirely correct. It is true that the southern winds which prevail all over the eastern United States during the summer pass over the Atlantic Ocean and the Gulf of Mexico and reach the land loaded with moisture. As soon, however, as they reach the land, part of the moisture is precipitated, and as they move farther inland they become drier and derive their moisture more and more from the evaporation from the land.

Of the 44,015,400 square miles of land surface of the earth 79 per cent drains directly toward the ocean and 21 per cent forms an in-

[1] Moore, W. L. A report on the influence of forests on climate and on floods. Washington, D. C., 1910.

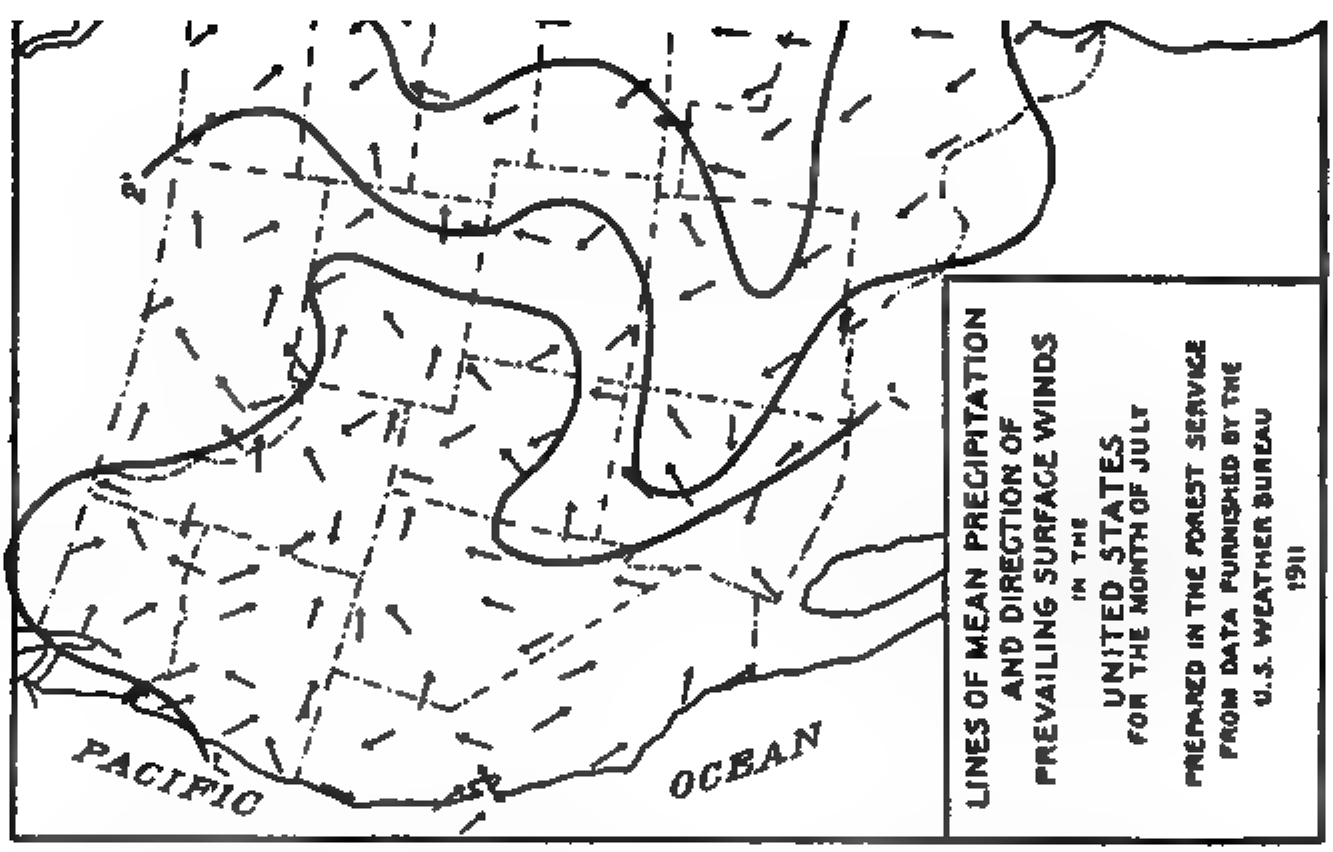
closed inland area without ocean drainage. The 79 per cent may be called the peripheral area of the earth's surface, and the importance of the evaporation from it is, on the whole, very great.



Prof. Ed. Brückner[1] computes the "continental vapor" evaporated from this peripheral area to be about 21,000 cubic miles (20,871.3 cubic miles). It plays, therefore, even a more important part in

[1] Brückner, E. Die Bilanz des Kreislaufs des Wassers auf der Erde. (Geographische Zeitschrift, v. 6; also in La Pedologie (Russian), 1905, v. 7, No. 3.)

supplying moisture to the air than does the vapor directly evaporated from the ocean. Brückner estimates that the peripheral regions of the continents are capable of supplying seven-ninths of their pre-



cipitation by evaporation from their own areas. If the evaporation from land plays such an important part in the precipitation over areas adjoining the ocean, it becomes still more important at some distance from the ocean. It may be assumed, therefore, that the

moisture which is carried by the winds into the interior of vast continents, thousands of miles from the ocean, is almost exclusively due to continental vapor and not to evaporation from the ocean.

In the interior closed basins the precipitation and evaporation are, as a rule, equal.

The circulation of water on the earth's surface may be shown in the form of a balance sheet, as follows:

Balance sheet—Circulation of water on the earth's surface.

	Cubic miles.	Depth, in inches.	Per cent.
A. Entire earth surface (196,911,000.59 miles):			
Evaporation from water surfaces	92,121	29.5	80
Evaporation from land surfaces	23,270	7.5	20
Precipitation on entire earth surface	115,391	37.0	100
B. Oceans (141,312,600 square miles):			
Evaporation from oceans	92,121	41.3	100
Amount of ocean vapor carried to the land (net [1])	5,997	2.8	7
	86,124	38.5	93
C. Peripheral land area (44,015,400 square miles):			
Ocean vapor (net)	5,997	8.7	29
Continental vapor from the peripheral land surface	20,871	29.9	100
Precipitation over the peripheral land area	26,868	38.6	129
D. Closed interior basins with no drainage to the ocean (11,583,000 miles):			
Evaporation from closed basins	2,399	13.0	100
Precipitation over closed basins	2,399	13.0	100

[1] The difference between the amount of vapor that escapes from land to the ocean and from the ocean to land.

An analysis of these figures discloses the fact that one-fifth of the entire vapor on the earth's surface comes from evaporation on land; that only 7 per cent, or 5,997.5 cubic miles, of all the water evaporated from the oceans enters into the precipitation over land; and that 78 per cent of all the precipitation that falls over the peripheral land area is furnished by this area itself.

Where is evaporation on land greatest? The evaporation from a moist, bare soil is, on the whole, greater than from a water surface, especially during the warm season of the year when the surface of the soil is heated. Soil covered only with a dead vegetable cover evaporates moisture much more slowly than a bare soil or an open water surface. On the other hand, a soil with a living vegetal cover loses moisture, both through direct evaporation and absorption by its vegetation, much faster than bare, moist soil.

The more highly developed the vegetal cover the faster is moisture extracted from the soil and given off into the air. In this respect the forest is the greatest desiccator of ground moisture. The experiments of Otozky, which have been fully confirmed by many observers in other countries, have conclusively shown that the forest, on account of its excessive transpiration, consumes more moisture, all other conditions being equal, than a similar area bare of vegetation or covered with some herbaceous growth.

The amount of water consumed by the forest is nearly equal to the total annual precipitation—in cold and humid regions less and in

warm and dry regions somewhat greater. This enormous amount of moisture, which is later given off into the air by the forest, may be compared to clouds of exhaust steam thrown into the atmosphere, and must necessarily play an important part in the economy of nature. If the southern and southeastern winds, in their passage toward the north, northwest, and northeast, in the spring and summer, did not encounter the vast forest areas bordering the shores of the Gulf of Mexico and the Atlantic coast, and those of the Southern Appalachian, and, therefore, were not enriched with the enormous quantities of moisture given off by them, the precipitation in the Central States and the prairie region would probably be much smaller than it is now. For the central interior region of the United States is the battle ground of two titanic forces, one harmful, the other beneficial. The beneficial one takes the form of the mild and humid summer winds from the Gulf of Mexico and the Atlantic Ocean, which at their height extend into the continent as far north as North Dakota, as far west as the foothills of the Rocky Mountains, and as far east as New England, and during the prevalence of which the rainfall in the eastern United States is heaviest. The other and harmful force is made up of the warm chinook winds which blow out of the northern Rocky Mountains, and the dry westerly winds of the upper Mississippi and the western lake region, both of which carry in their wake serious injury to orchards and fields. The Central States and the prairie region are geographically at the point where the battle between the two forces is fiercest, and the victory is now on one side, now on the other. When the humid southerly winds extend their influence far into the interior of the continent and overpower the dry continental winds, the Central States and prairie region, the granary of the United States, produce large crops. When the dry winds overpower the humid southerly winds there are droughts and crop failures.

As soon as the moisture-laden winds from the Gulf reach the land and encounter irregularities they are cooled and begin to lose part of their moisture in the form of precipitation. As long as the air currents remain saturated with moisture the slightest cooling or irregularity of the land that causes them to rise will result in precipitation. But as they move inland and become drier the remaining moisture is given off with difficulty, and precipitation decreases. The sooner the humid air currents over land are drained of their moisture, the shorter, of course, is the distance from the ocean over which abundant precipitation falls. If precipitation over land depended solely on the amount of water brought by the prevailing winds directly from the ocean, rainfall would, of course, be confined only to a narrow belt close to the sea. Not all the water that is precipitated, however, is lost from the air current. A large part of it is again evaporated from the land into the atmosphere. The moisture-laden air currents, therefore, soon lose the moisture which they obtain directly from the ocean, but in moving further into the interior absorb the evaporation from the land. Hence, the further from the ocean the greater is the proportion which evaporation from the land forms of the air moisture. In fact, at certain distances inland practically all the moisture of the air, or at least as great a part as that formed originally by the water evaporated direct from the ocean, must consist of that obtained by evaporation from the land.

In the case of the central and plain States, then, what would be the effect upon precipitation of complete or even partial destruction of forests in the Atlantic plains or in the Southern Appalachians? Since the mean temperature in the eastern portion of the United States drops rapidly from north to south, the moisture-laden air currents, upon reaching the land, would be cooled off and rapidly drained of their moisture within a comparatively short distance from the ocean. The sandy soil so characteristic of the southern pine belt of the Gulf and South Atlantic States would rapidly absorb the rain, without returning much of it into the atmosphere. The rain which fell upon the slopes of the mountains would rapidly run off into the streams. While the removal of the forest might increase the evaporation from the ground itself, yet the more rapid run-off and the absence of transpiration by the trees would reduce the total amount of water evaporated into the atmosphere. The land, even if taken up for agriculture, could never return such large quantities of rain into the atmosphere as the forests did. The result would be that less moisture would be carried by the prevailing winds into the interior of the country, and, therefore, less precipitation would occur there.

Regarding Sweden, an eminent meteorological authority, Dr. Hamberg,[1] says:

"The excess of evaporation which the forest vegetation of Sweden furnishes to the atmosphere above what the same area would furnish if it were covered only with herbaceous vegetation must, of course, be very considerable. If this aqueous vapor remained in the forest and returned to the land in the form of rain, it would be extremely beneficial. But winds carry it off and spread it in all directions with such rapidity that its beneficial influence for our country (Sweden) remains very doubtful."

The forests of Sweden have, however, an important influence upon the precipitation of the countries to the east, into which the prevailing winds blow, since in regions far removed from the ocean the feeding of the atmosphere by local evaporation has an important bearing upon the humidity and amount of precipitation. "On the continents, in countries like central Siberia," says Hamberg, "forest vegetation must influence, of course, the humidity of the air. It returns to the atmosphere in the form of vapor the water collected and conserved in the forest which otherwise would run off. It lowers the temperature of the air. As a result of these two causes, the relative humidity of the air must increase, and with it must also increase the inclination to precipitation in the form of rain or snow."

Whether mountain forests have the same effect as forests in level countries upon the precipitation of the regions into which the prevailing winds that pass over them blow, is difficult to determine. The problem is complicated by the fact that high mountain chains themselves exert an influence upon precipitation and the direction of the winds, not only by presenting a mechanical obstruction to the free passage of the air, but also on account of the difference in temperature on the different slopes. A moist current of air in passing over a mountain chain undergoes several changes. In ascending it becomes cooler, the temperature of air not fully saturated decreasing 1° F. for every 182 feet of ascension. At the same time, the water-

[1] Hamberg, H. E. De l'influence des forêts sur le climat de la Suède. Stockholm, 1885–1897.

holding capacity of the air decreases until the saturation point is reached, and fogs, clouds, and precipitation begin to form. Further cooling of the air in its upward course is counteracted to some extent by the heat that is separated in the process of condensing vapor, and from then on proceeds only at the rate of about 0.5° F. for every 182 feet of ascension. After the air current has passed the crest of the mountain and lost an amount of moisture in ratio to the degree to which it has been cooled, it descends on the leeward side and becomes heated. In its descent it absorbs the fogs and clouds, and in this process takes on some heat. Further heating goes on at the rate of 1° F. for every 182 feet of descent.

The more moisture the air loses in ascending a mountain the greater is the amount of heat it can absorb in descending. If, for instance, a current of saturated air, before ascending, had a temperature of 50° F., and the crest over which it passed was 9,900 feet high, then, on the leeward side at the same altitude at which it began to ascend, it would have a temperature of 77° F. and, provided no moisture is absorbed in the descent, a relative humidity of 21 per cent.[1] At other obstructions met by the same current of air the same changes would take place, though on the next chain of mountains new precipitation begins, as a rule, only at an altitude equal to that of the crest of the previous mountain chain over which the current of air has passed.

Prof. Mayr[2] has shown that wherever, as on the Pacific coast, in the Rocky Mountains, and in Caucasus and Turkestan, there are several parallel chains of mountains at right angles to the moist air current, each chain higher than the previous one, the forest on each consecutive mountain chain does not extend below an altitude equal to that of the preceding chain. Between the mountain chains are treeless, dry valleys.

As a rule the moist air currents passing over wooded slopes, being chilled, deposit most of their precipitation on the windward side. It is only in exceptional cases, such as when the air is not fully saturated, or when warm currents rise from below, that the air current, instead of depositing moisture, becomes enriched with moisture and carries it over the crest to the regions lying beyond. This may occur on southern slopes, which are likely to be warm. The influence of wooded windward slopes upon the humidity of the region to the leeward side of the mountains, therefore, varies. It is apparent, however, that while the forests in the mountains have a marked influence upon local precipitation, their influence upon the humidity of regions lying to the leeward can not, on the whole, be very great.

SUMMARY OF EFFECTS OF FORESTS UPON CLIMATE.

Accurate observations, continued for many years in different parts of the world, establish with certainty the following facts in regard to the influence of forests upon climate:

The forest lowers the temperature of the air inside and above it. The vertical influence of forests upon temperature extends in some cases to a height of 5,000 feet.

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[1] Klossovsky, A. V. Osnovi meteorologii. Odessa, 1910, p. 48.
[2] Mayr, H. Waldungen von Nord Amerika, Munich, 1890.

Forests increase both the abundance and frequency of local precipitation over the areas they occupy, the excess of precipitation, as compared with that over adjoining unforested areas, amounting in some cases to more than 25 per cent.

The influence of mountains upon precipitation is increased by the presence of forests. The influence of forests upon local precipitation is more marked in the mountains than in the plains.

Forests in broad continental valleys enrich with moisture the prevailing air currents that pass over them, and thus enable larger quantities of moisture to penetrate into the interior of the continent. The destruction of such forests, especially if followed by weak, herbaceous vegetation or complete baring of the ground, affects the climate, not necessarily of the locality where the forests are destroyed, but of the drier regions into which the air currents flow.

While the influence of mountain forests upon local precipitation is greater than that of forests in level countries, their effect upon the humidity of the region lying in the lee of them is not very great.

Forests as Conservers of Precipitation.

WATER AVAILABLE FOR STREAMFLOW.

All the water precipitated over an area covered with vegetation does not go to swell the underground drainage which feeds the springs and the regular flow of streams. Some of it is dissipated before it has a chance to reach the lower strata. A part (i) is intercepted by the branches and leaves of vegetation and is evaporated from them into the air; another part (e) is evaporated from the surface of the soil; a third part (r) runs off from the surface of the slopes into the valleys below; and a fourth part (t) is absorbed by plants and used by them for the building up of tissue and transpiration. Finally, a surplus (S), which is left over and above the amount absorbed by plants and evaporated by the soil, filters through into the ground and enriches the water which goes to supply the streams. Thus the water balance of any given area may be expressed in the form of an equation, in which $P=i+e+r+t+S$, and the amount of precipitation available for streamflow may then be expressed as $S=P-(i+e+r+t)$. Thus it is evident that, since the water available for streams is the amount which is left over and above that evaporated, transpired, and lost through surface run-off, the smaller the loss of atmospheric precipitation, the greater will be the amount of water that penetrates into the ground and becomes available for streamflow. Hence, to determine the effect of forests upon streamflow, it is necessary first to determine whether a greater or less amount of precipitation is dissipated in a forested than in a treeless region.

In a level country, where there is practically no surface run-off, the only sources of loss of water to the streams are interception by vegetation, evaporation from the soil, and transpiration. The water available for streamflow in a level country, therefore, may be represented by the equation $S=P-(i+e+t)$. In mountainous regions, on the other hand, surface run-off is one of the largest sources of loss to ground waters, and the hydrophysical influence of the forest in mountainous country is therefore essentially different from that in level country.

EFFECT OF FORESTS IN LEVEL REGIONS.

The forest, all other conditions being equal, has an influence distinct from that of any other vegetable cover upon the amount of precipitation lost to the streams. This influence varies, of course, with the kind of forest, just as the influence of field crops or of bare soil varies in accordance with the character of each.

INTERCEPTION BY TREE CROWNS.

On bare ground, for instance on a plowed field, it is self-evident that no water is lost through interception by vegetation. In a field or meadow from which the grass or crops have been removed interception by the vegetal cover is very slight. It is greater on fields with growing crops, and is greatest in the forest, especially when the trees are in leaf.

Many experiments have been carried on in different parts of the world to determine the amount of water intercepted by the crowns of trees. The results obtained vary considerably with the character of the trees, their age, density of crown, the amount and severity of precipitation, velocity and direction of the wind, etc. The amount of water retained by tree crowns is, however, not much greater than that retained by a meadow of dense grass or cultivated plants at the time of their full development. Ney[1] estimates, on the basis of the average number and weight of beech leaves shed, that the aggregate foliage of a middle-aged beech forest on 1 acre would occupy 8.4 acres, and on the basis of the average yield of straw and hay, that the aggregate area occupied by the foliage of cereals would be 7.4 acres; of clover, 5.6 acres; and of meadow grass, 4.8 acres. Though cultivated plants present less surface per acre than do beech leaves the latter offer more mechanical hindrances to the run-off of the water. It is very likely, therefore, that during the summer months cultivated fields retain as much water as does a beech forest.

For the entire year, however, the tree tops intercept more water than field crops, which are present for only a few months. The foliage in deciduous forests, on the other hand, remains intact for six months, and in coniferous forests all the year around. In deciduous forests, even when the foliage is gone, the branches still prevent a portion of the precipitation from reaching the ground directly. As a result of a great number of investigations,[2] it may be assumed that coniferous forests intercept more precipitation than broadleaf forests. Under average conditions a spruce forest will intercept

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[1] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

[2] Hoppe, E. Hegenmessung unter Baumkronen, Vienna, 1896; Fautrat, L. Influence comparée des bois feuillus et des bois résineux, sur la pluie et sur l'etat hygrométrique de l'air (Académie des science, Paris, Comptes rendus, 1877; Fautrat, L. Observations météroligique faites de 1874 à 1878. Paris, 1878; Krutzsch, H. Ueber den Einflus der Waldungen auf die Regenverhältnisse der germässgten Zone. (Tharander forstliches Jahrbuch, 1855, v. 11, pp. 123–141); Ebermayer, E. Die physikalischen Einwirkung des Waldes auf Luft und Boden. Berlin, 1873; Bühler, A. Die Niederschläge im Walde. (Schweizerische Centralanstalt für das forstliche Versuchswesen. Mitteilungen, 1892, v. 2, pp. 127–160); Ney, C. E. Ueber die Messung des an den Schäften der Bäume herabfliessenden Regenwassers. (Mitteilungen aus dem forstlichen Versuchswesen Oesterreichs, 1894, no. 17, pp. 115–125); Johnen, A. Comparative Beobachtungen der Neiderschläge nach Fautrat's Methode. (Centralblatt für das gesamte Forstwesen, 1878, p. 16–19); Riegler, W. Beobachfungen über die Abfuhr meteorlogischen Wassers entang den Hochstämmen (Mitteilungen aus dem forstlichen Versuchswesen Oesterreichs, 1881, v. 2, pp. 234–246); Mathieu, J. Météorologie comparée, agricole et forestière. Paris, 1878; Ebermayer, E. Untersuchungs-Ergebnisse über die Menge und Vertheilung der Niederschläge in den Wäldern (Forstlich natürwissenschaftliche Zeitschrifa, 1897, v. 6, pp. 283–301).

about 39 per cent of the precipitation, a broadleaf forest about 13 per cent. The amount of precipitation intercepted is the smallest in a young stand and greatest in a middle-aged one. This fact is clearly brought out by investigations conducted by Dr. Bühler in Switzerland in dense beech stands of different ages. The figures given in table 13 are averages for two to three years' observations:

TABLE 13.—*Interception of precipitation by tree crowns in beech stands of various ages.*

	Age of stand.			
	20 years.	50 years.	60 years.	90 years.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Proportion which reached the ground	98	73	77	83
Proportion retained by the tree crowns	2	27	23	17

The interceptive influence of forests is much greater in light than in heavy rains. It is evident, therefore, that all the figures which show the interceptive influence of tree crowns have a value only for the place and time that the measurements were taken, and for this reason can not be of general application. In regions where the precipitation is in the form of heavy or prolonged rains the ground under the forest, no matter whether the latter is deciduous or coniferous, will receive as much or nearly as much water as the bare ground, while in regions where the rains are neither heavy nor of long duration a large portion of the precipitation will remain in the tree crowns and escape the soil.

Of the precipitation intercepted by branches and leaves, however, only a part is evaporated into the air and so lost to the soil; the rest runs along the branches and trunks down to the ground. The amount of precipitation which reaches the ground along the twigs and trunks varies with the species, the bark, and character of branching. Thus, in a coniferous forest, the amount of precipitation which reaches the ground along the branches and trunks is very small (0.7 to 3 per cent), while in deciduous forests, under average conditions, it is about 15 per cent. Ney, after deducting from the amount of precipitation retained by the tree crowns the amount of water which runs down the trunks and branches, computed the loss of precipitation for the whole year, through interception by the crowns, to average for beech forests, 15 per cent; for pine, 20 per cent; and for spruce, 33⅓ per cent. Mathieu, at Nancy, on a basis of 11 years' observations, found that a forest of blue beech intercepts by its foliage and returns into the atmosphere on an average 8.48 per cent, and in winter only 5.85 per cent of the precipitation.

That portion of the precipitation which is prevented from reaching the ground directly is, however, not lost to the forest. Its evaporation increases the relative humidity of the air, which, together with the lower temperature within the forest, results in the condensation, especially in a coniferous forest, of a great deal of moisture, in the form of fog, dew, and hoarfrost.

Thus, though the forest, more than any other vegetable cover, intercepts atmospheric precipitation and prevents it from reaching

the ground, the amount of precipitation thus lost is offset, except in dense, old stands of pure spruce, by the greater precipitation over the forest and the greater condensation of vapor within it in the form of dew, hoarfrost, etc.

EVAPORATION FROM THE SOIL.

The influence of the forest upon evaporation has been determined for both water and soil surfaces. Numerous experiments on evaporation from water surfaces outside and inside the forest[1] have been carried on in France, Germany, and Russia. All these give practically the same result, namely, that evaporation from a free water surface is two and a half times greater outside the forest than inside.

Though investigations on the evaporation of water from soil surfaces were begun in the eighteenth century, and there are on record at least 50 different experiments, the results are less conclusive than those relating to the evaporation from free water surfaces.[2] According to the most accurate investigations, evaporation from bare soil in the open, under average conditions, amounts to about 50 per cent of precipitation. This ratio, however, varies within very wide limit. Ebermayer[1] and Wollney,[3] whose experiments are among the most accurate, determined in one case the evaporation from a bare sandy soil in the open to be 33.6 per cent of the precipitation, and that from a clayey soil, 50.8 per cent. In another experiment, where the kind of soil was not given, the evaporation was 49.4 per cent. Comparative observations on the amount of water evaporated by soil within the forest and in the open have been carried on chiefly by Prof. Ebermayer. These observations were made only during the summer on soils always kept at the point of saturation. The absolute figures, therefore, must be taken with considerable caution, but the ratio between the evaporation from soil in the forest and from a similar soil in the open which they show is extremely important. This is that the evaporation from forest soil without a cover of leaf litter is 39 per cent, and with a cover of litter 15.4 per cent of the amount evaporated by a similar soil in the open. If the same ratio holds for winter, then, within the forest, a soil covered with leaf litter evaporates only 7.7 per cent, and one without litter 19.5 per cent of the total annual precipitation.

It is fair to assume that in a pine forest which thins out with age the evaporation from the soil will be above the average. In a beech or other deciduous forest, with heavy, dense foliage, it will be less than the average.

Ney[4] determines the evaporation from the soil in a beech forest with leaf litter to be 6 per cent of the precipitation, without a leaf litter 15 per cent; in a pine forest with a leaf litter 15 per cent, without leaf litter 24 per cent; in a spruce forest with leaf litter 8.1 per cent, without leaf litter 19.5 per cent.

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[1] Ebermayer, E. Die physikalischen Einwirkung des Waldes auf Luft und Boden. Berlin, 1873.

[2] Ezera, K. Untersuchungen über den Einfluss der physikalischen und chemischen Eigenschaften des Bodens auf dessen Verdunstungsvermögen. Erlangen, 1844; Mangin, A. Influence des forêts sur le régime des eaux. (Revue des eaux et forêts, 1869.)

[3] Wollney, E. Des Einfluss der Pflanzendecke und der Beschattung auf die physikalischen Eigenschaften des Bodens. Berlin, 1877.

[4] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

The evaporation from soil in an open field covered with some vegetation has never been accurately determined, but, according to Ney, it scarcely exceeds one-third of the precipitation.

These results only confirm what one would expect of the influence which the forest has upon evaporation. The rate at which water is evaporated from the surface depends on the temperature of the air and soil, relative humidity of the air, movement of the air, and character of the soil cover. It has already been pointed out that the temperature of the air throughout the entire year and that of the soil in summer is lower within the forest than in the open; and that the relative humidity, especially in the summer, is greater in the forest than outside of it.

Wind.—The wind exercises a great influence on evaporation, both in summer and winter, by constantly renewing the air in contact with the moisture-containing surface. By breaking the force of the wind and checking the circulation of air, a forest cover reduces the evaporation of water or snow from the forest soil.

Mr. F. H. King,[1] of the agricultural experiment station of the University of Wisconsin, carried on in 1894 a number of interesting experiments to determine the effect of winds upon the rate of evaporation within and outside the sphere of influence of woods. The first series of experiments was made to the northwest of Plainfield, on a piece of ground planted to corn, south of a grove of black oaks having an average height of from 12 to 15 feet. At the time of the experiment there was a gentle breeze from a little west of north. The results showed in one case that the evaporation at 20 feet from the wood was 17.2 per cent less than at 120 feet. In another case, at three stations located within 60 feet of the woods, the amount of evaporation was 24 per cent less than at three stations located between 280 and 320 feet away from the woods. Another experiment near the town of Almond, to the south of an oak grove 80 rods square, in a field sowed to oats and wheat, showed that the amount of evaporation increased until a point 300 feet from the woods was reached. Here the evaporation was 17.7 per cent greater than at 200 feet and 66.6 per cent greater than at 20 feet from the woods, the difference being due entirely to the protection from the wind afforded by the forest.

Observations made by the Forest Service on the influence of windbreaks[2] upon crops have shown that the per cent of moisture saved within an area 12 times as wide as the height of the trees may amount at different wind velocities to from 11 to over 40 per cent.

Character of soil cover.—As already shown the soil cover in the forest, composed of a mulch of fallen leaves and humus, reduces considerably the amount of moisture evaporated from the ground. Experiments conducted by Prof. Ebermayer for five years (1869–1873) in Bavaria demonstrated that a layer of fallen leaves is capable of reducing evaporation from the soil by 24 per cent. Thus, while the average evaporation from the soil in the forest deprived of leaf litter during the summer months (May to September) amounted to 39

[1] King, F. H. Influence of woods on the rate of evaporation and amount of moisture in the air over fields to the leeward of them. (Wisconsin—Agricultural experiment station. Bulletin 42, 1894, pp. 14–19.)

[2] Bates, C. G. Windbreaks: their influence and value. Wash., D. C., 1911. (U. S.—Dept. of agriculture—Forest service. Bull. 86.)

per cent of that in the open, the evaporation from the same soil covered with a fairly deep layer of leaf litter was only 15 per cent of that in the open. In other words, while the forest cover alone diminished the evaporation from the ground by 61 per cent, the forest cover, together with the leaf litter, reduced it by 85 per cent.

Evaporation from soil in the open decreases greatly, of course, with increase in altitude; yet the forest cover, together with the leaf litter still exercises its influence, although the difference between the evaporation in the open and that in the forest at high altitudes is not so great as at lower ones.

The lower summer temperature of the soil and air in the forest, the greater relative humidity of the air, the checking of strong air currents, together with the double protection afforded to the soil by the mulch of fallen leaves and humus and the tree tops, tend to reduce the direct evaporation from the soil in the forest to practically a negligible quantity as compared to that in the open.

TRANSPIRATION.

Besides the loss of water through direct evaporation from the soil, a large amount is returned to the atmosphere by the transpiration of leaves. This may be called physiological evaporation, in distinction from physical evaporation, since it is essential to the physiological function of the tree.

Loss of water through transpiration is one of the most complicated physiological processes. Although the problem has received a great deal of attention and has been studied by a large number of investigators, the exact quantities of water transpired by different trees and plants are still unknown. What the experiments thus far have established are the comparative amounts transpired by different plants. Of the experiments carried on upon the amount transpired by forest trees those of Wollny, Höhnel, and Bühler are the most valuable since they were carried on for long periods of years and with the utmost care.

Höhnel determined the consumption of water by forest trees by repeated weighings of the pots containing them, and determined the loss of water through transpiration by the difference between successive weighings.

In Table 14 are brought together the results of Höhnel's experiments. The table is of especial interest in that it gives the comparative water consumption of different species. The figures are only for the vegetative season, and show the number of pounds of water transpired for every pound of dry-leaf substance.

TABLE 14.—*Amount of water transpired by different forest trees per pound of dry-leaf substance.*

	1878	1879	1880
	Pounds.	*Pounds.*	*Pounds.*
Birch	679.87	845.13	918.00
Ash	566.89	983.05	1,018.50
Hornbeam	562.51	759.01	871.70
Beech	472.46	859.50	913.80
Maple (Spitzahorn)	462.87	517.22	611.80
Maple (Bergahorn)	435.77	618.30	703.80
Elm	407.31	755.00	822.80
Oak	283.45	622.21	691.50
Oak (Zerreiche)	253.33	614.22	492.20
Spruce	58.47	206.36	140.20
Scotch pine	58.02	103.72	121.05
Fir	44.02	77.54	93.80
Austrian pine	32.07	99.92	70.05

Thus, during the vegetative period, birch and ash trees transpire for every pound of dried-out leaves from 567 to 1,019 pounds of water—more than do any other forest trees; beeches and maples from 436 to 914 pounds; oaks from 253 to 692 pounds; and conifers, which transpire least, from 32 to 206 pounds. The difference in the amount of transpiration in the different years is explained by the fact that the years 1879 and 1880 had more rain and therefore more water penetrated the soil.

Höhnel estimates that a fully stocked beech stand, 115 years old, consumes from 1,560 to 2,140 tons of water per acre, or 1.15 acre-feet per year. The last means that if the water were spread over an acre it would have a depth of 1.15 feet. If an acre contains 526 trees from 50 to 60 years old, the water consumption is only 1,026 tons per acre, or 0.70 acre-foot; and if it contains 1,620 trees, only 35 years old, the consumption is as low as 321.5 tons per acre, or 0.23 acre-foot. Höhnel expressed the quantities of water that were transpired in 1880 in per cent of the precipitation of that year. He found that elm transpired 43½ per cent, beech 25 per cent, and birch 40 per cent of the precipitation. In 1878 and 1879 the per cent of transpiration was smaller.

Wollny, in observations carried on for six years, determined the amount of water transpired by different species of trees in pots, containing identical amounts and kinds of soil, by measuring the amounts of water which percolated through the pots. He found that spruce transpires, on an average, during the year 37.9 per cent of the annual precipitation and birch 27.8 per cent; but that during the vegetative period the amount transpired by the two species is almost the same, spruce 33 per cent and birch 32.1 per cent.

Ney [1] computed, on the basis of Höhnel's results, the amount transpired during the entire vegetative season by beech as 10.8 inches, spruce 8.3 inches, and pine 2.9 inches; or, for the forest in general, 7.3 inches. This, expressed in per cent of the total precipitation (31.5 inches), would be 23.2. In the case of coniferous trees the amount transpired during the winter must be taken into account, so that the transpiration of pine for the entire year would be 3.1 inches (10.2 per cent of the total precipitation) and for spruce 9.1 inches (28.9 per cent of the total precipitation).

[1] Ney, C. E. Der Wald und die Quellenbildung. (Forstwissenschaftliches Centralblatt 1901, p. 452.)

TOTAL AMOUNT OF WATER LOST TO STREAMS.

Loss of water to streams through interception by tree crowns and ground cover, by evaporation from the ground, and by transpiration, in a level country with no surface run-off, may be summed up for different kinds of forest, as in Table 15.

TABLE 15.—*Loss of water to streams in forests in level country (annual precipitation 31.5 inches).*

	Interception by forest cover.	Evaporation from soil.	Transpiration.	Total loss.	Total loss of annual rainfall.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Per cent.*
With leaf litter:					
Beech	6.7	1.9	10.8	19.4	61.5
Pine	9.4	2.8	3.1	15.3	48.6
Spruce	12.1	2.6	9.1	23.8	75.6
Average	9.4	2.4	7.7	19.5	61.9
Without leaf litter:					
Beech	4.7	4.7	10.8	20.2	64.1
Pine	6.3	7.6	3.1	17.0	54.0
Spruce	10.5	6.1	9.1	25.7	81.6
Average	7.2	6.1	7.7	21.0	66.7

On the basis of Wollny's and Riesler's experiments Ney has determined the total annual loss of water from field crops through interception of precipitation by the plants, evaporation from the soil, and transpiration to be as shown in Table 16.

TABLE 16.—*Loss in water to streams from field crops.*

	Total loss.	Annual precipitation (31.5 inches).
	Inches.	*Per cent.*
Meadow (overflowed)	41.6	132.1
Potato field	13.5	42.9
Grain field	25.3	80.3
Field crops in general	19.4	61.6

On bare soil in level country the only loss is from evaporation from the soil. This amount has been found to be on an average about 50 per cent of the precipitation.

The figures given, which are corroborated by daily practical experience, show that in a level country a soil covered with vegetation of some kind surrenders to the ground waters a much smaller amount of water than bare soil with no vegetation at all; and a forest, at least a spruce forest, less than field crops. The only vegetative cover which uses up more water than a spruce forest is an overflowed meadow, which can draw upon a supply of water in addition to the precipitation. That any vegetable cover in a level country tends to reduce the amount of water available for streamflow is clearly shown by numerous experiments. In the United States King[1] has

[1] King, F. H. Observations and experiments on the fluctuations in the level and rate of movement of ground water (U. S.—Weather bureau. Bulletin 5, 1892, p. 32).

demonstrated this for corn. During the growing seasons of 1899 and 1890 the mean height of ground water under corn was lower than that under fallow land. From this he inferred that corn exerts a measureable influence in depressing the height of ground water lying at a depth of over 7 feet below the surface.

Recent experiments in Russia by Ototzky and others, taken with those by German and French investigators, have brought out the fact that in a level country with ground waters not in motion the humidity of the forest soil, which is very great at the surface, rapidly decreases with depth. According to Evermayer, this desiccating influence extends under spruce stands to 31.5 inches, and, according to Russian investigators, even to from 10 to 13 feet. The forest, like any other vegetable cover, desiccates the layer of soil within which its roots are active, and since the roots of forest trees go to a much greater depth than the roots of cultivated crops, this has led to the conclusion that forest cover absorbs more moisture, and therefore desiccates the soil to a greater depth, than any other vegetal cover.

These investigations, of which those carried on by Prof. Henry in the forest of Mondòn, near Luneville, France, must be considered the most conclusive, have established with sufficient accuracy that in the forests of a level country, in a temperate or cold climate, where the geological strata are homogeneous and horizontal, and the ground water is, therefore, not in motion, and where there is no surface run-off, (1) the water table is lower under the forest than outside during every season of the year, and (2) this depression is more marked in regions with deficient precipitation than where the precipitation is great.

Ototzky's and Henry's experiments can not, however, be generalized for all species and for all level countries of the world, since there are species and level regions where just the reverse is true. Thus, for instance, in level tropical regions, where the heat is intense, and the bare soil, though it may receive large quantities of rain, is subject to great evaporation, the soil under forest cover, in spite of intense transpiration, may contain more moisture than that in the open, especially since transpiration in tropical climates during the period or rest, which occurs in the hot season (equivalent to the winter of the temperate zones), is considerably reduced, while evaporation, which follows physical laws, is especially intense at that time. B. Ribbentrop[1] reports that wells from 6 to 10 feet deep, dug within the forest plantations in the suburbs of Madras, near Trichinopoli, British India, contain water during the hottest season, while neighboring wells, 15 feet deep, outside of the forest, and rivers in the vicinity, are entirely dry during the hot months. This is due to the enormous evaporation from the bare soil during the hot months, evaporation which is much greater than the transpiration from the forest cover.

It is also true, as Ney has shown, that, from the consumption of water by different forest trees, it may be inferred that in a level country the cutting away of such forests as beech or spruce may even lead to an increase in ground waters. The cutting away of pine forests in a level country would, however, be injurious to ground

[1] Ribbentrop, B. Influence of forests on the climatic conditions and fertility of a country. (In his Forestry in British India, 1900, pp. 39–59.)

waters unless the soil should remain entirely bare, for any other vegetation which would take the place of pine would consume a larger amount of water and, therefore, tend to lower the ground water to a greater extent than the pine forests.

The lowering effect on ground waters of the forest is well known from practical experience. The afforestation of the swamp lands of southern France, called the Landes, with maritime pine, brought about a lowering of the water table. In Italy the water table in swamps has been lowered by planting eucalypts, and in many swampy regions in Europe the drainage ditches, which before afforestation were always full of water, after planting became entirely dry.

As a net result of all these experiments in different parts of the world, it must be admited that a difference exists between the hydrophysical influence of the forest in the plains and that of forests in the mountains and hills. In the plains the forest, because of its desiccating effect upon the soil:

(1) Constitutes an effective means of draining and drying up swampy lands, the breeding places of malaria and swamp fevers. The reforestation of the Landes, Sologne, the Pontine marshes, and a hundred other examples prove this.

(2) It draws moisture from a greater depth than does any other plant organism, thus affecting the unutilized water of the lower horizontal strata by bringing it again into the general circulation of water in the atmosphere, and making it available for vegetation.

(3) While it lowers to some extent the subterranean water level, it has no injurious effect upon springs, since these are practically lacking in the level countries with horizontal geological strata where its lowering influence has been chiefly noted.

(4) It refreshes the air above it and increases the condensation of moisture carried by the winds, thus increasing the frequency of rains during the vegetative season.

EFFECT OF FOREST IN MOUNTAINOUS REGIONS.

INTERCEPTION, EVAPORATION, AND TRANSPIRATION.

In mountainous regions, as already shown, the amount of precipitation increases within certain limits with elevation. The denser the forest cover, the greater is this increase. Forests in the mountains receive more precipitation than forests at lower altitudes in the same region.

The loss of precipitation through interception (i) by tree crowns and humus in mountainous regions, while it has never been measured accurately, is accepted to be less than in level regions, first, because in the mountains precipitation more often falls in heavy showers, and second, because a larger part of it is in the form of snow.

In mountain forests the loss through direct evaporation (e) from the soil is considerably less than in forests of a level country, because of the lower temperatures at higher altitudes.

The amount of water transpired (t) by a forest in the mountains is also less, for the vegetative period is shorter, the temperature lower, and there is, in consequence, less growth per unit of area. This is well illustrated by the variation in the amount and weight of

leaves produced by the same species at different altitudes. At an elevation of 450 feet, 1,000 beech leaves have an aggregate surface of 36.7 square feet, but at an elevation of 4,500 feet this falls to 9.8 square feet. Not only the surface and weight of the same number of leaves decrease with increase in altitude, but the ash content decreases as well. At a height of 450 feet, the ash content of beech leaves is 9.91 per cent, and of fir needles 10.19 per cent. At an elevation of 3,500 feet, that of beech is 4.03 and of fir 3.58 per cent.

Thus in mountain forests everything tends to reduce loss of precipitation, through interception, evaporation, and transpiration, to a minimum, and, consequently, to increase the amount of water available streamflow.

Observations carried on in forests over a broken topography, where the geological strata are not horizontal, and the ground waters therefore in motion, and where there is a surface run-off, have failed to establish any lowering of the water table under the forest. On the contrary, Hartmann,[1] hydraulic engineer of the State of Bavaria, who carried on these investigations in cooperation with the Bavarian Forest Service at the initiative of the International Association of Forest Experiment Stations, found that the water table at Mindelheim (altitude 2,000 feet) was nearer the surface in the forest than outside.

SURFACE RUN-OFF CONVERTED TO SEEPAGE.

In the mountains the greatest source of loss of precipitation is through surface run-off (r), and the most important influence which a forest cover has is in reducing this.

A German investigator of high standing (Ney) estimates the amount of water which the forest cover saves to the soil by reducing the surface run-off and changing it to underground seepage to be as follows: For forests at low altitudes where the rains are not heavy and the soil is less subject to freezing, 20 per cent; for forests of moderate altitudes, 35 per cent; and for mountain forests, 50 per cent of the precipitation.

Measurements of surface run-off made in 1860 by Jeandel, Cantegril, and Bellot[2] in the Vosges, show that the surface run-off from the wooded slopes is only about half as much as that from deforested slopes, while, from the former, the underground seepage is greater and the flow of the streams more regular.

Such an authority as Huffel[3] states that under ordinary conditions of railfall there is practically no surface run-off from wooded watersheds having an abundant leaf litter.

The saving of precipitation effected in this way by the forest is more than sufficient to offset whatever loss may be sustained through transpiration or interception by tree crowns. This is clearly brought out by the following facts: The entire loss of water from forested areas at moderate altitudes, even on the steepest slopes, is about equal to that from forest in level country.[4] Ney places this at 19.4 inches

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[1] Ebermayer, E., and Hartmann, O. Untersuchungen über den Einfluss des Waldes auf den Grundwasserstand. Munich, 1904.

[2] Jeandel, F., Cantegril and Bellot. Études experimentales sur les inondations. Paris, 1862.

[3] Huffel, G. Études experimentales sur les inondations. Paris et Nancy, 1862.

[4] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

or 61.5 per cent of the precipitation (31.5 inches). Cultivated fields on similar slopes have been computed to lose, through interception by vegetable cover, evaporation from the soil, transpiration, and surface run-off, 24.9 inches, or 79 per cent of the precipitation, and bare surfaces 27.2 inches, or 86.4 per cent. The higher the altitude, the steeper the slope, the heavier the rainfall, and the greater the precipitation, the more marked will be the difference. This holds true, not only for such species of trees as beech or pine, the entire loss of water from which is less than that from cultivated fields, but also for spruce. Although in a level country a spruce forest consumes more water than do cultivated fields, at high elevations, where the precipitation is from 43 to 47 inches, it consumes only 9.2 inches, or 21.5 per cent of the total precipitation, less than open fields and nearly 15.7 inches or 34 per cent less than bare surfaces.

The ability of the forest to check surface run-off is greatest when the ground beneath is covered with an unbroken leaf litter. A forest without leaf litter, on slopes at moderate altitudes, has little effect in checking run-off. The entire loss of precipitation from such a forest was found to be 26.9 inches, while that from bare surface in the same situation was 27.2 inches. Hence, for a forest to exercise its most beneficial effect upon run-off, it must not be burned over, grazed, or otherwise interfered with in its normal function.

That a normal forest in the mountains saves more water for streamflow than any other vegetal cover or any bare surface is shown also by the abundance of springs in mountain forests.

This difference in the hydrological influence of the forest in level country and in the mountains makes clear how unfounded is the contention occasionally expressed that if the forests are to control streamflow it is necessary to keep them not only on the headwaters of the stream, but also on their lower levels, since the latter form by far the largest part of the drainage basin. As carefully conducted experiments have shown, the presence of forests at low levels, especially spruce, may impoverish the ground waters instead of enriching them. At best, the influence would be the same of that of agricultural soil kept in good tillage. A forest in the mountains, on the other hand, actually conveys more water to the ground than does any other vegetal cover. The greatest influence of a forest upon streamflow, therefore, is at high altitudes, where precipitation is heaviest, slopes steepest, and erosion easiest. Even if good agriculture, as sometimes claimed, could have there the same effect upon erosion and absorption of water as forest cover, which it has not, the fact would be of no practical value, since agriculture at high altitudes is, as a rule, impracticable.

Reduction of surface run-off means both an increase of underground seepage and prevention of erosion, two important factors in the regulation of streamflow. The action of mountain forests in protecting the soil against erosion and in increasing underground seepage at the expense of surface run-off is the result of their ability to lessen the severity of rainfall, to retard the melting of snow, to offer mechanical obstacles to surface run-off, to hold the soil together, to keep it in a permeable state, to increase its volume by constantly adding new soil, and to absorb large quantities of water by its leaf litter.

Severity of rainfall checked.—The amount of water which filters into the ground depends, for one thing, upon the length of time the water remains in contact with the soil. For slopes of the same gradient this, in turn, depends upon the duration of the rain, or on the time the snow takes to melt. Imbeaux[1] found, for deforested or poorly forested watersheds near Mirabeau, that during three exceptional rainfalls the surface run-off from slopes of the same gradient constituted in one case 33 per cent, in another 39 per cent, and in a third 42 per cent of the precipitation, while during less heavy rains this per cent fell to 22, and in light rains to 18. Other figures obtained at the confluence of the Durance with the River Rhone were close to those obtained at Mirabeau, but somewhat smaller. For the Danube, near Vienna, Lauda, the Central Hydrographic Bureau, using the same method, found that for the period between July 28 and August 14, 1897, the surface run-off formed 42 per cent of the precipitation.

The forest modifies both the severity and the duration of the rainfall. By its foliage and branches it breaks the force of the rain, so that the water reaches the soil without violence and at the same time prolongs its duration. After a storm water continues to drip from the leaves and twigs for one or two hours. The water in the forest, therefore, falls more quietly and for a longer time and has thus a better chance to be absorbed by the soil.

Melting of snow retarded.—The rapid melting of the snow in the spring, especially when the ground is frozen or is saturated with water, favors surface run-off and lessens seepage. In this country the systematic measurement of snow in the mountains has but recently been begun by the Weather Bureau in cooperation with other bureaus, and it will be several years before definite results are obtained.[2] Such measurements, however, have been made in other countries, and the influence of the forest upon the melting of snow has been thoroughly determined by experiment, especially in Russia, where snow forms a large portion of the precipitation and affects most vitally the flow of streams.

At the Imperial Agronomic Institute at Moscow measurements on the amount of snow that reaches the ground in the forest have been carried on for five years, both by means of rain gauges and directly by measuring the snow cover in the forest before its melting. These measurements show very clearly that the species, density, and age of the forest have a direct influence upon the amount of snowfall that reaches the ground. Thus, while in a birch stand between 70 and 75 years old only from 4 to 5 per cent of the total snowfall is prevented from reaching the ground, in dense spruce stands the tree crowns retain from 50 to 55 per cent. In other words, only about half as much snow reaches the ground in a dense spruce forest as in the open. This is brought out in Table 17.

[1] Imbeaux, E. Essai programme d'hydrologie. (Zeitschrift für Gewasserkunde, 1898–1899, v. 1, pp. 68–91, 225–278; v. 2, pp. 220–248, 257–274.)
[2] U. S.—Department of agriculture—Weather bureau. Instructions no. 76.

TABLE 17.—*Interceptive influence of forests on snowfall.*

	Number of areas examined.	Number of measurements of snow depth.	Number of snow samples weighed.	Thickness of snow.			Water equivalent of snow depth.	Amount of water per acre.
				Minimum.	Maximum.	Average.		
				Inches.	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*
1. Young plantations (2 to 4 years old) and small clearings within the forest	20	259	7	15.4	26.8	21.9	5.1	18,420
2. Birch forest (35 to 75 years old)	11	377	27	18.9	26.8	22.2	5.0	18,290
3. Oak forest (25 and 90 years old)	2	63	3	19.7	27.2	23.5	5.6	20,148
4. Pine forests	32	887	56	11.4	19.7	15.5	3.1	11,256
Young (25 to 35 years old)	25	662	43	11.4	19.7	15.2	3.1	10,417
Old (60 to 90 years old)	7	225	13	11.8	19.3	16.4	3.2	11,497
5. Spruce forest (25 to 35 years old)	21	460	29	6.7	13.8	9.7	2.1	7,711
6. Pine forest with admixture of birch (65 to 75 years old)	4	6	3	14.2	22.8	20.0	4.4	15,753
Pine forest with admixture of larch (25 to 35 years old)	3	74	2	11.4	16.5	15.2	3.1	11,230
Pine forest with admixture of spruce (35 years old)	5	157	9	8.7	15.7	12.9	2.9	10,391
7. Spruce forest with admixture of larch	3	57	2	8.3	21.7	14.1	3.1	11,108
8. Cultivated field	1	332	8	5.1	22.4	13.0	3.1	11,281

Thus, an acre of broadleaf forest (birch 35 to 75 years old, and oak 25 to 90 years old) will contain per acre about 41 per cent more snow water than a pure pine forest (20 to 90 years old); 60 per cent more more than a pure spruce forest; or an average of about 50 per cent more than coniferous forests in general. The table shows also that the age of the stand has an important influence upon the amount of snow on the ground. Thus, young pine stands contain from 9 to 10 per cent more snow than older pine stands (60 to 90 years old). The important fact which these figures show, however, is that young forests, deciduous forests, and small openings within the forest collect nearly twice as much snow as open fields, while dense, pure spruce forests contain less than open fields.

Upon the comparative loss of snow, through drifting or evaporation, from forested and from unforested areas, there exists comparatively little data. This is due chiefly to the great difficulty of making satisfactory measurements on the wind-blown and constantly shifting snow in the open. Such meteorological observations and empirical data as do exist, however, agree in showing that the loss of snow in the forest during thaws in the winter and from other causes is much less than that outside. This is due, as in the case of aqueous precipitation, to the protection afforded by the forest cover from the direct rays of the sun and from radiation, to the lesser circulation of the forest air, and to the narrower range of temperature inside the forest than outside. Because of this protection from the sun and wind, and also because of the partial retention of the spring rains by the forest cover, the melting of snow in the forest continues for three, four, and five weeks longer than in the open.

The influence of forests in retarding the melting of snow has been demonstrated with especial precision in a 10 years' series of observations carried on at the Imperial Agronomic Institute at Moscow. These show that the period of snow melting lasts within the forests from 26 (1904) to 57 (1902) days, while snow in the open disappears

within 6 or 7 days. Thus, in 1908, the melting of snow, which began April 12, lasted in the forest until May 15 (34 days), but in the fields, pastures, and all other open places surrounding the institute, only until April 22 (11 days), while in the more exposed fields the snow had all disappeared as early as April 18, 7 days after it had begun to melt. The retention of snow in the forest until May 15 was in spite of the fact that after April 22 there were frequent warm rains.

The rapidity with which snow melts in the forest varies with the species, and with the density, age, and location of the stand. This variation has been found to hold true from year to year, irrespective of the weather at the time of melting. The snow disappears first of all from clearings in the forest, simultaneously with its disappearance from open fields. Next it disappears from young forest plantations, in which the tree tops have not yet begun to touch each other, then from thin oak forests on southerly slopes, and old, open pine forests; then from dense stands of birch on northerly slopes; later from pine, and last of all from spruce. Thus, in 1908, at the Imperial Agronomic Institute, the ground in field and forest became entirely free of snow on the following dates:

In fields, clearings, and open places	April 22.
In young, open stands	April 24.
In old, open stands on south slopes	April 26.
In birch stands	April 29.
In pine stands	May 6.
In spruce stands	May 15.

Thus, while compared with deciduous stands, coniferous forests, and especially pure dense spruce, prevent large accumulations of snow, their effect in retarding its melting, especially in the case of spruce, is much greater, and for this reason they are more efficient in reducing the height of spring freshets.

In an ordinary forest region the water in the streams in the spring is derived from three sources: (1) The snow water that runs off from fields and clearings; (2) the surface run-off from forest soil, however slight; and (3) one, one and one-half, or two months later, after all the snow is melted, the underground water. With the destruction of the forest the ground water is greatly decreased, there is no longer the retarded surface run-off from forest soil, and nearly all the snow water runs off at once as surface water from the fields and cleared land.

In cultivated fields and clearings in the north the ground is still frozen when the snow melts. This, together with the rapid melting of the snow in the open, causes the water soon to run off, even from gentle slopes, in great quantities, as though from the roof of a building. Freezing of the ground in fields and clearings is due chiefly to unimpeded radiation in the fall and to the blowing away of the protective cover of snow in the winter. Cultivated ground freezes especially deep during the winter if saturated with rain water at the time of the first fall frost. Surface run-off from open fields is further increased when thaws during the winter coat the ground under the snow with an icy sheet, over which the snow waters run off in the spring without penetrating the ground.

In the forest, on the other hand, the soil is warmer than in the open. It is protected from radiation by trees. It is further pro-

tected by the leaf litter, a poor conductor of heat, which both prevents its cooling off and protects it from freezing in winter, and, in the processes of fermentation and decay, contributes the heat which these evolve. The relatively even cover of snow on the ground protects it still further. Under this triple protection the forest soil either does not freeze at all or freezes much later in the winter and to a much less depth than in open places. Moreover, it thaws out in the spring while still under its cover of snow. The slow melting of snow in the forest, together with the unfrozen, or only slightly frozen, condition of the ground beneath, permits a much greater percolation there than in the open. This water-holding capacity of the northern forest is more marked in coniferous stands, especially in spruce.

Closely connected with the relatively high temperature of the forest soil is another important fact which is often entirely overlooked. If the soil of watersheds remains soft and unfrozen, the ground water which feeds the streams continues to flow throughout the winter, thus keeping up the normal winter water stages in the streams under the ice. If, however, the flow of underground water ceases during the winter, the water accumulates in the ground, small streams freeze to the bottom, and the water stage of the river falls. In spring the ground water which has accumulated behind the icy dams thus formed at the bottoms of slopes bordering the streams enters the rivers in large quantities. For the regimen of rivers, therefore, the importance of forest cover on slopes bordering springs, creeks, and small streams, which are fed by underground waters, is especially great.

Surface run-off obstructed.—The forest floor, penetrated by a network of roots and covered by branches and stumps, offers many obstructions to the surface run-off and so permits the water to sink into the ground. Percolation is made still easier by the presence of deep channels in the soil, left by the decay of large roots.

The porosity or permeability of the soil has a great influence on the amount of surface run-off. The influence of the forest, therefore, will vary with the character of the soil on which it grows. On heavy clay or other impermeable soils the crowns of trees, which break the violence of the rainfall, together with a surface mulch of leaves and twigs, prevent the soil from becoming compact and allow it to retain its granular structure, thus making it more permeable to water. On a soil very permeable to water, such as sand, the influence of the forest in decreasing surface run-off may be very insignificant, consisting chiefly in preventing the soil from being washed away.

An unbroken forest soil cover of half decomposed leaf mulch and humus aids greatly in retarding surface run-off and forcing it to penetrate into the ground. Its importance in this respect is made clear by the following facts: The leaf mulch on an acre of virgin beech forest weighs, when air-dried, about 8,818 pounds; in a pine forest, 15,873 pounds; and in a spruce forest, 12,346 pounds. If the specific gravity of the air-dry leaf litter be only 0.5, then the dry substance of the leaf mulch if evenly distributed over an acre would cover it in a beech forest to a depth of only 0.08 inch, in a pine forest to 0.14 inch, and in a spruce forest to 0.11 inch. In nature, however, this amount of leaf litter covers the ground in beech and pine forests

to a depth of 3.1 inches, and in a spruce forest to a depth of 3.9 inches, which gives an idea of the space within the leaf litter and of the volume of water it may accommodate.

Hüffel found that a forest with leaf litter, after a rainfall of from 2.4 to 2.8 inches, did not give off, even on the steepest slopes, a drop of water in the form of surface run-off. If water does not run off from such stands it comes from the precipitation which falls on an area deprived of its forest cover—for instance, a road.[1]

To determine precisely the actual effect of different kinds of forest soil in retaining the water which they receive as rain or melting snow, Prof. E. Henry [2] conducted a series of experiments with typical soils from spruce and beech forests. Taking the greatest care to preserve the natural arrangement and solidity of the soil, a number of samples were removed, thoroughly saturated by plunging into water for several days, drained of the excess moisture, and weighed. After being thoroughly dried at a temperature of 100° C. (212° F.) the samples were reweighed, and the weight of water held by the saturated soil thus determined. From the average of all the weighings it was found that the spruce-needle humus contained, when saturated, 4.15 times its own weight in water, while the beech-leaf humus contained 5.38 times its own weight. When simply air-dried, which is, of course, the case in nature, beech-leaf humus was found still to absorb 4.41 times its weight, while air-dried spruce humus took up about 3.38 times its weight.

To ascertain the actual amount of water absorbed and retained per given unit of area by spruce and beech humus, the average weight of oven-dried (100° C.) humus per 2½ acres was determined. Allowing 15 per cent for excess moisture content of air-dried over oven-dried humus, the air-dried spruce and beech humus were found to have a retentive capacity of approximately 46.44 and 22.2 tons of water per acre, respectively. This amounts in volume to 1,510 cubic feet per acre for spruce and 712 cubic feet for beech humus, equivalent to a rainfall of 0.41 inch and 0.2 inch, respectively.

The depth of soil has a bearing upon the amount of water which it can retain. No matter what its character may be, a thin soil can not retain much water. The forest, however, tends to increase the volume of soil, and thus creates greater reservoirs for water. It does this in two ways: (1) From above, by the addition of leaves and twigs, which, when decayed, become a constituent part of the soil; and (2) from below, by inducing disintegration and decomposition of the underlying rock. The forest, by constantly increasing the depth of the soil, lessens the likelihood of it being washed away and enables it to remain where it was formed. The addition of organic matter to the soil increases its water-holding capacity. The tree roots at the same time enter the narrow fissures of the rock, which they widen, thus producing many new openings into which the water may sink.

During the vegetative season the demand of the forest upon the water stored in the ground is very great. In summer the forest, like other crops, consumes more water than it receives in the form of precipitation. At the end of the vegetative season, therefore, the level

[1] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

[2] Henry, E. Influence de la couverture morte sur l'humidité du sol forestier. (Annales de la science agronomique, 1901, tome 2, 182–196.)

of the underground water is low. As a result, the forest soil can absorb large quantities of water during the period of vegetative rest, when there is an excess of water on the ground, either from heavy rains or from the melting of snow. The forest soil, therefore, forms a reservoir whose capacity is greatest when the excess of water on the ground and the danger of floods is greatest. The water stored in the time of rest is used by vegetation and for the flow of streams later on when there is usually a deficiency of precipitation.

SUMMARY OF THE EFFECTS OF FORESTS IN CONSERVING PRECIPITATION.

(1) The hydrological rôle of forests in level countries differs from that of forests in hilly or mountainous regions.

(2) In level country, where there is no surface run-off, forests, in common with other vegetation, act as drainers of the soil; hence their importance in draining marshy land and improving hygienic conditions. In such country their effect upon springs is unimportant.

(3) In hilly and mountainous country forests are conservers of water for streamflow. Even on the steepest slopes they create conditions with regard to surface run-off such as obtain in a level country. Irrespective of species, they save a greater amount of precipitation for streamflow than does any other vegetable cover similarly situated. They increase underground storage of water to a larger extent than do any other vegetable cover or bare surfaces. The steeper the slope the less permeable the soil, and the heavier the precipitation the greater is this effect.

(4) In the mountains, the forests, by breaking the violence of rain, retarding the melting of snow, increasing the absorptive capacity of the soil cover, preventing erosion, and checking surface run-off in general, increase underground seepage, and so tend to maintain a steady flow of water in streams.

FORESTS AND EROSION.

One far-reaching influence of the forest upon streamflow lies in its ability to protect the soil from washing. Wherever the topography is at all rough, erosion of the soil is a factor to be dealt with. The extent to which soil is eroded depends upon the climate, steepness of the ground, the character of the soil, the geological formation of the region, and the surface cover. When the slopes are steep, the soils and the underlying rock friable, the rains torrential, and the surface bare of vegetation, erosion by surface run-off reaches colossal proportions. In such regions thousands of acres of fertile soil are destroyed each year and millions of cubic feet of silt deposited in the bottom of rivers to form bars and shoals which change the regimen of the streams and obstruct navigation.

Erosion on cleared slopes above the headwaters of streams, where agriculture is impracticable, may be prevented by sodding, by a growth of shrubs, by engineering work such as log or rock dams in deep gullies, or by covering the surface with straw, leaves, and brush. The most permanent, effective, and cheapest protection against erosion, however, is a forest cover. Grass, while effective in preventing erosion, does not diminish the surface run-off and serves no other useful purpose. A surface blanket of straw, leaves, and brush is

only a palliative, and must eventually be replaced by some permanent cover. Engineering work is, as a rule, very expensive, and alone will not fully accomplish the purpose sought. Where the soil has been entirely washed away, however, engineering work of some sort is necessary before any vegetable cover can be started.

The forest is the most effective agent for protecting the soil from erosion because (1) the resistance of the soil to erosive action is increased by the roots of the trees, which hold the soil firmly in place, and (2) at the same time the erosive force of the run-off is itself reduced, because the rate of its flow is checked and its distribution over the surface equalized.

France furnishes a good example of the effect of forest cover upon erosion and streamflow. There some 800,000 acres of farm land had been ruined or seriously injured as a result of clearing about the headwaters of streams, and the population of 18 departments was reduced to poverty and forced to emigrate. In 1860 forest planting was begun on the headwaters of the streams. Already 163 torrents have been entirely controlled by this means, and 624 more are beginning to show the effects of forests on their headwaters. Thirty-one of the torrents now entirely controlled were a half century ago considered hopelessly bad. The foremost French engineers, after many experiments, have come to the final conclusion that forest cover is one of the most effective means for checking erosion and that the best place to control streamflow is at the headwaters of the streams. Examples of reforestation of mountains for the control of torrents are to be found not only in the French Alps, but also in the Swiss Alps and in Tyrol.

Erosion has a bearing on the height of flood water in the rivers, since the sediment carried by the rivers and the coarser detritus brought down by mountain streams often increase stream volume to such an extent that the height of the water is raised far beyond the point it would reach if it came free of detritus and sediment. When the channel of a stream has become filled with waste material—even a slight rainfall will cause a flood, while, if the channel were deep, it would have no perceptible effect upon the height of water in the stream. The filling of mountain streams with waste not only increases the frequency of floods, but causes the streams to assume the character of torrents. A channel filled entirely or partially with foreign material can not hold large quantities of water, while the denuded slopes deliver the storm water almost as fast as it falls.

How great may be the volume of detritus carried by a given volume of water is shown by Demontzey,[1] who computed that one mountain torrent brought down in 85,020 cubic yards of water 221,052 cubic yards of detritus, or more than two and a half times its own volume.

L. C. Glenn[2] ascribes the change in regimen of many of the mountain streams in the Southern Applachian to the denudation of the steep mountain slopes and the consequent erosion. He finds conclusive evidence of increased erosion, the result of clearing on the mountain stream basins since 1885, in the character of the flood-plain deposits within recent years. When floods are small or gentle the

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[1] Demontzey, P. Traité pratique du reboisement et du gazonnement des montagnes. Paris, 1882.

[2] Glenn, L. C. Denudation and erosion in the Southern Appalachian region and the Monongahela Basin. Washington, D. C., 1911. (U. S.—Geological survey. Professional paper 72.)

flood-plain deposits consist of fine aluvium. When the floods are great and violent the deposits consist of coarse sand, cobbles, and bowlders. In the past the flood-plain deposits of such southern rivers as the Watauga, the Doe, the Nolichucky, the French Broad, the Catawba, and the Yadkin, were built of fine sandy loam or clay. In the last decade, however, the deposits have grown coarser, which points to an increase both in the height and in violence of floods.

In mountainous regions where a thin soil covered with forest is underlaid with hard rock, such as limestone, or with unfertile formations, such as chalk, destruction of the forest may often result in the complete desolation of the region. As long as the soil, formed during centuries by the disintegration of the rock and the accumulation of humus, is held together by the roots of trees, some ground waters may accumulate within it, or even small springs may be found. As soon, however, as the forest is removed the thin soil is washed, even from gentle slopes, and nothing remains but bare rock. Examples of this kind are common all over the world and may be found even in this country, in spite of the fact that here destruction of the forests is comparatively recent, and consequently erosion has not progressed as far as in some portions of the Old World. There, as in Karst, portions of Greece, Palestine, and the mountainous provinces of southern France and Italy, the evils of forest destruction and subsequent erosion are strikingly evident.

In Karst deforestation has practically converted the region into a desert. The burning sun now strikes the naked rocks, from which the atmosphere is heated by radiation, while the rain is lost in the rock fissures, without benefit to vegetation. For many square miles the country is one of drought.

In the United States the effect of destruction of forest cover upon erosion is most impressively shown by the conditions prevailing in the Ducktown copper region, Tennessee. Smelters started about 16 years ago near Ducktown have killed, by sulphuric fumes, all vegetation in their immediate vicinity. The slopes are now bare and are being rapidly eroded. On Potato Creek this eroded material is accumulating at the rate of a foot or more each year and has buried telephone poles almost to their cross arms. On Ocoee River each flood deposits large quantities of sand and periodically dams the river. The country for several miles has become a barren waste.

Of all vegetable covers, forests are most efficient in preventing the slopes from eroding and the beds of streams from filling with silt. Even on very permeable soils, where their effect upon the underground storage of water may be of secondary importance, they are necessary as protection against erosion.

PART II.—RESULTS BY THE HYDROMETRIC METHOD.

Reliability of Available Records of Stream Measurements.

Measurements of the flow of waters in streams from forested and unforested watersheds would theoretically be the best check upon the conclusions obtained by the physical method. Actual measurements of streamflow, however, have not lead to such conclusive results as have the data secured by the physical method; nevertheless, the concensus of opinion among the leading authorities in engineer-

ing and forestry the world over is that the forest exercises a potent influence in the regulation of streamflow. It is true that there is a very considerable divergence of opinion on the extent of this influence. Close study, however, traces this to the complexity of the problem and the failure to give due weight to the factors involved, as well as to the needless confusion arising from the introduction of factors which have no bearing on the subject.

While in many countries observations on the behavior of streams date back a number of years, most of them suffer from lack of exact measurements of stream discharge over a period of years long enough to neutralize exceptional conditions, and also from lack of accurate records of the condition of the drainage basin during the same period.

In this country there are about 287 rivers which are classed as navigable. Of these scarcely 25 per cent have any kind of coextensive records of precipitation and stream measurements covering periods of more than 15 years. In Europe records of stream measurements for some rivers, like the Seine, at Paris, have been kept since 1732; for the Elbe, near the town of Madgeburg, since 1728; for the Rhein, since 1770. But these measurements, also, are not of such a character as to enable one to draw accurate conclusions with regard to the effect of forests upon streamflow. Even in Germany there are not more than two or three rivers for which any records of scientific value are available.

With the exception of a carefully planned experiment by the Swiss Government and a similar experiment started in the Rocky Mountains by the Forest Service, no thoroughly accurate studies of this problem have been made anywhere. In practically none of the American investigations, and in very few of the European streamflow studies, have accurate records existed of the condition of the cover on the catchment basins, though in some cases the changes in the cover are roughly referred to for the period under investigation. The mere statement that lumbering has been carried on in a given watershed, while in another watershed no logging has been done, is not a sufficient proof that the beneficial influence of the forest cover on the former has been impaired, while on the other it has not. A logged-over area may contain young reproduction, the effect of which upon the run-off may be just as favorable as virgin forest. On the other hand, a virgin forest, if repeatedly burned or grazed and thus deprived of its leaf litter, may cease to exercise its normal beneficial influence upon the surface run-off. Thus, in discussing the relation between precipitation and forest cover, the statement has recently been made that in New England, where logging began early in the history of the United States, the average precipitation showed a slight decrease during a certain period (since 1836 up to a few years ago). From this statement it was sought to convey the inference that forest destruction and precipitation have no relation to each other. As a matter of fact, New England alone, of all sections in the United States, has, during this period, actually been gaining in the area under forest cover.

It is a matter of common observation and knowledge to anyone who travels through New England that many abandoned fields are going back to young, thrifty stands of forest, and actual statistics show a perceptible increase in the forest area of such States as New

Hampshire and Vermont. In addition, there has been, especially in recent years, a marked decrease in the use of woodland for the pasturage of stock in this part of the country. How misleading are conclusions based on the mere fact that logging has been carried on in certain watersheds is indicated by the conditions existing through the Southwest, especially in southern California. There, on the lower edges of the forest, a constant struggle is going on between it and the chaparral. Any setback to the commercial forest, such as destructive lumbering or fire, gives at once an advantage to the chaparral growth which permits it to occupy the place of the other. Though the commercial forest is reduced in area, this may have no visible effect upon streamflow, provided the chaparral takes its place, since the latter may have a similar influence on the surface run-off. It is not enough to show in any given case that the forest area has been reduced; it must be shown that the forest has not been replaced by some cover, natural or artificial, which affords a similar protection to the soil.

Deductions made from deficient data secured in limited regions have often been generalized as applying to all rivers, climates, and conditions. In order to bring out the true relation between surface cover and streamflow the conditions must be studied separately for each stream. The effect of the forest on streamflow is different in different climates. It varies with the abundance, character, and distribution of the precipitation, and with temperature. In regions with severe winters, abundant snowfall, and sudden springs, all other conditions being equal, the effect is greater than in humid climates with prolonged, drizzling rains.

The effect of the forest varies further with the geological formation, topography, and size of the watershed, as well as with the depth and character of the soil. On steep, impermeable soils the effect of the forest is greatest; on deep sandy soils it may be insignificant. In some basins the geologic formation and the dip of the strata are such that as much as 10 per cent of the precipitation is allowed to escape by deep underground passages and so entirely lost, at least to the given drainage basin.

The character of the stream and its tributaries, the slope or gradient of the stream, the presence of falls and rapids, the section of the stream, the arrangement of the tributaries, and the presence of natural storage reservoirs, all have an important bearing upon the character of the flow in the stream. They may also obscure or increase the effect of forest cover. The artificial use of streams for irrigation or for water supply may again obscure the true effect of the forest on the regulation of its flow.

Observations of the factors affecting stream flow, like precipitation, stream discharge, and forest condition, in order to yield conclusive results, must be carried on for long periods of time, covering not only a few years of extreme conditions, but also embracing periods of climatic fluctuations.

The height of the water in a river may rise or fall with a change in the character of the bed, yet the amount of the water discharged by the river may remain the same. This change, for instance, may be caused by silting of river beds. In order to obtain reliable data as to the discharge of rivers, it is therefore necessary to measure not only the height of the water, but also the rapidity of the flow,

since both of these affect the discharge. This, however, has been done on very few rivers, either here or abroad.

Most of the studies of streamflow so far made have been confined to large river basins of many thousand square miles. On such there exist many conditions of soil, topography, and vegetative cover, which counteract each other and obscure the relation that may exist between the behavior of the stream and any one of these factors. Recently the International Association of Forest Experiment Stations abroad has realized that the relation of soil cover to stream flow can not be satisfactorily studied from observations on rivers with large drainage basins, and the central forest experiment station at Zurich, Switzerland, is now carrying on intensive observations on two drainage basins, one with an area of 140 acres and the other of 175 acres. For the same reason the Forest Service, in its intensive study of the relation of forest to streamflow, now being carried on in the Rocky Mountains on the Rio Grande National Forest, has selected two watersheds of 212.3 and 222.7 acres, respectively.

A great many observations have been carried on on the lower portions of large rivers. These are misleading, since they are the result of the diverse conditions prevailing on the various tributaries.

The method of computing the results of stream gaugings and precipitation has a most important bearing upon the problem. By averaging the records of stream gaugings and precipitation for two periods, for which the regimen of the stream is compared, it is possible entirely to obscure the effect which forests might have had on the flow of water. By working up the data separately for each storm it may be possible to show much more fluctuation in one period than in the other. Thus, Prof. Willis Moore, Chief of the United States Weather Bureau, by computing the average annual river stage of the Ohio River at Cincinnati for two periods between 1871–1889 and 1890–1908, as well as the average precipitation for the two periods, found that both the flow of the Ohio River and the precipitation over its watershed did not vary perceptibly in the two periods under comparison. On the other hand, Mr. M. O. Leighton, Chief Hydrographer of the United States Geological Survey, by comparing the annual precipitation and the number of days in each year that the gauge registered 20 feet and above on the Ohio River at Wheeling, W. Va., clearly showed a change in the behavior of the river during the period between 1896–1907 as compared with the period 1885–1895.

The importance of all these factors has been recognized only within comparatively recent years, and scientific methods of studying the relation of forest to streamflow, even abroad, have not been followed for very long. No thorough observations extend very far back, therefore, on any of the European rivers, and less so on our own rivers. Any attempt to base conclusions upon inexact observations of streamflow made before the present scientific methods were introduced leads only to groundless speculation and confusion. A striking example of this is given by the Tiber, with the exception of the Nile perhaps, the most historic of rivers. It has so far proved impossible to ascertain whether the floods of the Tiber have increased or diminished in the course of centuries, owing to the fact that the incomplete records lend themselves to conflicting conclusions. Under these circumstances it is clear that the American records, as well as the European, can show at most only tendencies, though these tendencies may be so marked as to justify important inferences.

RECORDS OF AMERICAN RIVERS.

A general study made by the United States Geological Survey and the Forest Service of the changes which have taken place in the flow of rivers in the United States, during the time for which records have been kept, revealed the fact that in many streams, particularly in those which rise in the eastern mountains, there has been, during the past 20 or more years, a marked and steady increase in the fluctuation of all the river stages and in the duration of high and low waters. Of especial importance is the work of M. O. Leighton,[1] Chief Hydrographer of the United States Geological Survey, whose report to the National Conservation Commission is not only the first systematic attempt at a broad and comprehensive review of river discharge records in the United States, but also marks a departure in the method of computing the river discharge records.

It has already been pointed out that a comparison of average river stages for two periods can not prove or disprove the effect of forest cover upon streamflow. Prof. Moore's method of comparing the average annual discharge and precipitation for the Ohio River in each of the 19-year periods for which records are available simply proves that the average annual discharge of the Ohio River in each of the periods has been the same. Since practically as much rain fell in the one period as in the other, it is no cause for surprise that the stream's average was the same for both. It has been lost sight of that the average flow in one of the periods might be made up of comparatively uniform stages, and in the other of many short and sharp floods with intervening low stages. It is as unsafe to rely on averages to show changes in a stream's regimen as it would be to rely on accidents. Indeed, instead of bringing out the facts sought, averages conceal them.

The method which Mr. Leighton used was that of comparing the annual precipitation with the number of days in each year that the gauge at a given point on a river registered above a certain stage, and using the relation of the number of days of flood to the precipitation as an indication of the changes in the regimen of a given river during two periods under observation. Results were worked up for decades as well as for each individual year, since the former bring out more clearly the trend of the changes. The data analyzed by Leighton relate to the Ohio River at Wheeling, W. Va., and to its three principal tributaries, the Allegheny, the Youghiogheny, and the Monongahela, and to the Wateree River above Camden, S. C., the Savannah above Augusta, Ga., the Alabama above Selma, Ala., the Connecticut at Holyoke, Mass., and the Tennessee River above Chattanooga. These records were presented in the form of a series of diagrams, which show that, during the period 1885–1907, inclusive, the ratio of high river stages to annual precipitation increased on the Ohio River at Wheeling, W. Va., from 0.38 in the period between 1885–1895 to 1.48 in the period between 1896–1907. The Allegheny River at Freeport, Pa., showed for the period 1874–1907, inclusive, an increase in the ratio from 0.86 in the first half to 1.04 in the second half. For the period 1886–1907, the Monongahela River

[1] Leighton, M. O. Floods. (National conservation commission. Report, 1909, v. 2, pp. 95–107.)

showed an increase of the ratio from 0.49 in the first half to 0.55 in the second half. In the Youghiogheny River there was also an increase of from 0.35 in the first half to 0.47 in the second half of the period 1875–1906, inclusive. The southern rivers showed similar increase in the ratio of high river stages to annual precipitation. For the Wateree River at Camden, S. C., this was from 0.41 to 0.51; for the Savannah at Augusta, Ga., from 0.24 to 0.29; for the Alabama at Selma, Ala., from 0.18 to 0.28. In the Connecticut at Holyoke, Mass., there was also a marked increase of from 0.86 during the period 1874–1890 to 0.95 during the period 1891–1907.

In obtaining the ratio between the number of days of high river stages and the annual precipitation, Leighton divided the number of days in each year that the gauge at a given point on a river registered above a certain stage by the total annual precipitation. For the Tennessee River, however, he compared the number of flood days with the number and depth of flood-producing rains. The latter method is the more accurate, but because of the enormous amount of labor involved it was applied only to the Tennessee River. The results secured for this river show that, although during the last half of the period studied the number of days of flood were less than during the first half, the rainfall decreased in an even greater degree. A comparison of the average annual river stages for the two consecutive 12-year periods for which coextension records of streamflow and precipitation are available would show a decrease in the high river stages during the second period. By comparing, however, the number of days of high river stages with the number of days of individual rain storms of sufficient magnitude to produce flood conditions, Leighton brought out the fact that there has been an increase in the number of high river stages in proportion to the rainfall, the average percentage of increase in the last 12 years as compared with the 12 years previous being 18.75.

In analyzing the causes of this marked change in the behavior of a large number of streams, Leighton found that the cutting of the forest on the watersheds of these rivers is responsible for the change in their regimen, as all other factors, such as climate, topography, and geology remained the same, and no artificial storage or drainage affected in the slightest degree the flow of the rivers under discussion. The same conclusion has been reached by Hall and Maxwell,[1] of the Forest Service, who worked up the records of the Weather Bureau relating to stream gauging and precipitation for 10 important rivers. The results of their survey are given in Table 18.

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[1] Hall, W. L., and Maxwell, H. Surface conditions and streamflow. (U. S.—Department of Agriculture—Forest service. Circular 176, 1910.)

TABLE 18.—*Flood and low-water records for 10 important rivers.*

FLOODS INCREASED.

Name of stream.	Point of measurement.	Area of basin.	High-water stages taken in this table.	Low-water stages taken in this table.	First and second periods of record. Years.	First and second periods of record. Duration.	High-water data. Number of floods.	High-water data. Days of floods.	High-water data. Average times per year of floods.	High-water data. Average days per year of floods.	High-water data. Times of last period compared with first.	High-water data. Days of last period compared with first.	Low-water data. Number of low stages.	Low-water data. Days of low stages.	Low-water data. Average times per year of low stages.	Low-water data. Average days per year of low stages.	Low-water data. Times of last period compared with first.	Low-water data. Days of last period compared with first.	Precipitation. Number of stations.	Precipitation. Mean (inches).	Precipitation. Mean annual increase or decrease (inches).
		Sq. mi.	Ft.	Ft.		Yrs.					Per ct.	Per ct.					Per ct.	Per ct.			
Potomac	Harpers Ferry, W. Va.	9,363	12	3	1890–1898	9	19	33	2.11	3.55	[1] 136.80	[1] 72.70	54	1,351	6.00	150.00	[1] 40.7	[1] 25.3	5	36.81	+.13
					1899–1907	9	26	57	2.77	6.33			76	1,693	8.44	188.00			5	37.97	
Monongahela	Lock 4, Pennsylvania	5,430	20	7	1886–1896	11	30	55	2.73	5.09	[1] 73.00	[1] 82.00	66	912	6.00	83.00	[1] 36.33	[1] 7.33	6	42.25	—.08
					1897–1907	11	52	100	4.73	9.09			90	979	8.17	89.00			6	41.35	
Ohio	Wh eling, W. Va.	23,820	22	5	1882–1894	13	46	143	3.54	11.00	[1] 28.25	[1] 31.50	79	1,333	6.08	112.50	[1] 39.00	[1] 20.75	11	41.74	—.14
					1895–1907	13	59	188	4.54	14.40			110	1,609	8.46	123.70			11	39.90	
Cumberland	Burnside, Ky	3,739	25	3	1890–1898	9	32	89	3.55	9.90	[1] 34.40	[1] 14.60	61	1,261	6.77	138.00	[1] 6.50	[1] 27.00	3	46.27	—.54
					1899–1907	9	43	102	4.77	11.33			65	1,576	7.17	175.00			3	41.42	
Wateree	Camden, S. C.	5,135	20	6	1892–1899	8	46	147	5.75	18.37	[1] 35.00	[1] 22.00	115	1,164	14.37	145.50	[2] 44.30	[2] 56.40	3	45.46	+.25
					1900–1907	8	70	187	7.75	23.50			64	508	8.00	63.50			3	47.48	
Savannah	Augusta, Ga.	7,300	20	6	1890–1898	9	47	116	5.22	12.77	[1] 23.40	[1] 46.50	70	566	7.70	63.00	[2] 41.00	[2] 48.00	3	48.12	—.17
					1899–1907	9	58	170	6.44	17.77			41	292	3.56	32.00			3	46.58	
Tennessee	Chattanooga, Tenn.	21,418	24	2	1874–1890	17	32	173	1.88	10.18	[1] 3.13	[2] 20.80	71	902	4.17	53.00	[2] 22.53	[1] 8.86	5	53.17	—.37
					1891–1907	17	33	137	1.94	8.06			55	982	3.24	57.70			5	46.83	
Allegheny	Freeport, Pa.	9,220	16	2	1874–1890	17	39	92	2.29	5.41	[1] 35.90	[1] 42.40	99	1,747	5.82	102.70	[2] 8.10	[1] 35.00	4	41.65	—.32
					1891–1907	17	53	131	3.12	7.70			91	1,136	5.35	66.80			4	36.17	

FLOODS DECREASED.

Name of stream.	Point of measurement.	Area of basin.	High-water stages taken in this table.	Low-water stages taken in this table.	Years.	Duration.	Number of floods.	Days of floods.	Average times per year of floods.	Average days per year of floods.	Times of last period compared with first.	Days of last period compared with first.	Number of low stages.	Days of low stages.	Average times per year of low stages.	Average days per year of low stages.	Times of last period compared with first.	Days of last period compared with first.	Number of stations.	Mean (inches).	Mean annual increase or decrease (inches).
Wabash	Mount Carmel, Ill.	26,300	15	3	1890–1898	9	21	351	2.33	39.00	[2] 9.50	[2] 20.50	38	1,365	4.22	152.00	[2] 15.75	[2] 15.00	5	39.54	—.40
					1899–1907	9	19	279	2.11	31.00			44	1,160	4.93	129.00			5	35.99	
Red	Arthur City, Tex.	40,200	20	4	1892–1899	8	19	87	2.37	10.87	[2] 16.00	[2] 30.00	49	826	6.12	103.25	[2] 83.60	[2] 74.80	5	31.80	—.24
					1900–1907	8	16	60	2.00	7.50			8	208	1.00	26.00			5	29.86	

[1] Increase.

[2] Decrease.

The results indicate that the tendency of the rivers examined is toward greater irregularity in the flow of water. The period for which coextensive records of precipitation and stream measurements exist were divided into two equal parts and a comparison made of high and low water stages for the two halves of the period Of the 10 rivers examined 8 showed greater river stages in the last half than in the first half of the period. As in Leighton's work, it was not the average annual stages of the rivers which were compared for the two periods, but the actual number of days of high and low river stages and their duration.

Both the Geological Survey and the Forest Service have compared, not the highest floods that have occurred in the two periods under observation, but definite high river stages. Extreme stages of the rivers, such as excessive floods and aggravated droughts, are accidents, due to abnormal conditions or chance combinations of circumstances and can not be relied upon to prove or disprove changes in a stream's regimen. If a stream discharges its water more spasmodically or more regularly than formerly, its habit has changed, whether excessive floods or droughts occur oftener or not. Thus, on the Passaic River, according to the State Geologist[1] of New Jersey, a rate of 24 cubic feet per second per square mile was reached only two or three times during 17 years, for a few days in each case, whereas the stream stood at stages between 0.4 and 1.34 cubic feet per second per square mile on an average of 112 days yearly, and between 1.34 and 3.35 cubic feet on an average of the same number of days each year. It is evident, therefore, that the really important thing to determine on the Passaic would be a cause affecting these moderate stages of the river, as they are of a greater economic value than the extreme stages, which are of infrequent occurrence.

The method employed, therefore, by the Geological Survey and the Forest Service is the only one that could be relied upon to determine whether the river's habit is changing. The results brought out by Leighton, Hall, and Maxwell would be still more convincing if they were based on longer periods of observation, on the actual discharge of rivers, and were accompanied by evaporation records. They are, however, the best available. Moreover, since in no other country in the world have surface conditions changed on so large a scale and so quickly as in the United States, the effects of forest cover upon streamflow should be very marked, even within the short period for which observations exist. The rivers examined by Leighton, Hall, and Maxwell are not the only ones which show a change in their regimen with a change in the surface cover.

A number of other records exist to show that the flow of water in streams has undergone a considerable change with the change in the surface cover of the watershed, but lack of supplementary records, such as those for the precipitation, make it impossible to show conclusively that this change is entirely due to reduction in the forest cover. Thus, Perkiomen Creek, a large tributary of the lower Schuylkill River, draining 360 square miles, has been measured regularly since 1883. The records show that during the 10 years, 1885 to 1894, the average minimum flow was 20.8 second-feet, while in the 11 years, 1895 to 1905, it was 17.4 second-feet; or, in other words,

[1]Vermeule, C. C. Forests and Water Supply. (New Jersey—Geological survey. Annual report, 1889, pp. 137–172.)

that the minimum flow during the last period was 16.3 per cent less than in the first half of the period. The average maximum during the first 10 years was 4,908 second-feet, against an average maximum of 5,330 second-feet during the 11 years following, or 9 per cent greater. There has undoubtedly been a considerable change on the watershed of this creek, but the assumption that the less uniform flow during the latter 11 years is due to the change of the surface cover alone can not be safely accepted until it can be shown that all other factors affecting streamflow have remained unchanged during this period.

Rafter[1] found the maximum flow of the Genesee River, whose watershed is entirely deforested, to be over three times as great as that of the Hudson, whose watershed is 90 per cent in forest, and its minimum flow to be just a little over one-fourth as great. The maximum observed flow of the Hudson from 1887 to 1898 was at the rate of 13.2 second-feet per square mile, and the minimum 0.29 second-feet; on the Genesee the maximum flow, 1890 to 1896, was about 40 second-feet per square mile, and the minimum flow 0.08 second-feet.

Farley Gannett[2] mentions an example of two streams in Delaware County, Pa., measured by Henry Birkinbine. These two streams drained adjoining areas, and weirs were placed on each at a point above which the drainage was 1 square mile. One stream flowed through woodland and the other through open country. The measurements showed that, following rains, the open stream flowed almost invariably more water than the forested one, and that during droughts the reverse was the case.

The importance of the underground water in feeding the dry-season flow of streams is very apparent from the behavior of three streams, of which one has a forested, the second a cultivated, and the third a barren watershed, during the different seasons of the year. Table 19, which is taken from the report of the State Geologist[3] of New Jersey, gives the computed daily run-off in gallons per square mile during the last eight months of the dry year of 1881.

TABLE 19.—*Computed run-off, in gallons, daily per square mile, from forested, cultivated, and barren watersheds during the last eight months of 1881.*

	Passaic, forested.	Raritan, cultivated.	Barren watershed.
April	597,000	754,000	631,000
May	297,000	325,000	145,000
June	272,000	272,000	139,000
July	207,000	134,000	22,000
August	140,000	89,000	22,000
September	139,000	87,000	23,000
October	129,000	84,000	22,000
November	127,000	93,000	23,000

In the three spring months, April, May, and June, the forested watershed yielded 61 per cent of its flow for the eight months from April to November, inclusive, while the cultivated area yielded 73 per cent and the barren drainage area 89 per cent. This is the high-

[1] Rafter, G. W. The application of principles of forestry and water storage to the mill streams of New York. N. Y., 1899.

[2] Gannett, Farley. What stream gaugings indicate as to the run-off from forested and barren areas. (Engineering news, 1910, v. 63, pp. 759–760.)

[3] Vermeule, C. C. Forests and water supply. (N. J.—Geological survey. Annual report, 1899, p. 163.)

water season of most streams and is the season during which the ground storage is taking place. In the next three months the forested watershed yielded 25 per cent of its flow for eight months, the cultivated 16 per cent, and the barren watershed 6 per cent. In the last two months the forested watershed yielded 13 per cent, the cultivated 10 per cent, and the barren 4 per cent. This shows how small is the underground storage in barren watersheds.

On the basis of this difference in the behavior of the three rivers, the State geologist computes that the Passaic River, with its forested watershed, will furnish for nine months of the year per 100 square miles of watershed 45 horsepower, or 10 feet fall, whereas the Raritan (cultivated watershed) will furnish only 41 horsepower, and the barren watershed 28 horsepower. During the other three months the Passaic will furnish an average of 36, the Raritan 32, and the barren watershed 20 horsepower.

Mansfield Merriman,[1] in his survey of the Delaware River between Trenton, N. J., and Easton, Pa., pointed out, even as early as 1873, the great frequency with which high-water stages occurred then as compared with the time previous to 1835. Previous to 1835 floods of 12 feet at Lambertville were considered very high, while 14 feet had been attained only three times within the memory of man, in 1776, 1801, and 1814. After 1835, however, water stages of 14 feet became common, while in 1841, 1846, and 1862 three floods occurred, during which probably one-third to one-half more water was discharged than during any previously known. Merriman does not hesitate to attribute this increase of the high-water stages to the clearing away of the forest in the river basins, "which previously exercised a protective action in restraining the percolation of the rainfall through the soil, and thus insured to the river a more even flow of water than at present."

An inquiry among engineers regarding the influence of forest upon streamflow, made by the National Conservation Commission in the fall of 1908, showed that the majority of engineers in this country are of the opinion that forests affect the regularity of flow of water in streams. Of the 171 replies received from active, associate, and junior members of the American Society of Civil Engineers, 151, or about 89 per cent, mentioned rivers and creeks the regimen of which has changed to their knowledge after a reduction of the forest cover on the watersheds. Only about 20 replies were to the effect that personal observations upon the flow of water in rivers showed no direct connection between forests and stream flow.

Records of European Rivers.

In Europe the effect of forests upon streamflow was pointed out by hydrographers as early as in the thirties of the last century. Thus in 1837, a hydrographer of note, Dr. Heinrich Berghaus, on the basis of his observations upon the Elbe and upon the Oder, from 1778 to 1835, showed that the amount of water in these rivers was gradually decreasing, and attributed it to the destruction of forests, cultivation of the soil, and the draining of swamps. The effect of forests upon

[1] Merriman, M. Survey of the Delaware River between Trenton, N. J., and Easton, Pa. (U. S.—War Dept.—Engineer Dept. Report, 1893, Appendix U 19, pp. 899–921.)

streamflow, however, was brought to the front in 1873, when an Austrian hydrographer, Gustave Wex, published the results of a number of actual measurements of the discharge of five of the most important rivers of Europe, the Rhine, Elbe, Oder, Vistula, and Danube. His measurements were confined chiefly to the medium and low stages of these rivers. In table 20 are shown the results of the measurements, reduced to a 50-year period.
forests.

TABLE 20.—*Measurements of flow in five European rivers.*

Name of the stream and gauge station.	Periods of observation and their duration in years.	Decrease in the height of medium stages during the half period of observation.		Increase or decrease in the mean flood stages during the half period of observation.	Decrease in the height of the mean stages reduced to a period of 50 years.	
		Of lowest stages.	Of annual stages.		Of lowest stages.	Of annual means.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Rhine at Emmerich.....	1770-1835 (66 years)..	13.64	16.91	+ 0.85	20.65	25.62
Rhine at Düsseldorf.....	1800-1870 (71 years)..	-.62	4.87	+ 8.84	-.85	6.86
Rhine at Cologne........	1782-1835 (54 years)..	7.42	4.40	+15.44	13.73	8.14
Rhine at Germersheim..	1840-1867 (28 years)..	Unknown.	17.12	Unknown.	Unknown.	61.16
Elbe at Magdeburg.....	1728-1869 (142 years).	29.86	31.92	- 9.27	16.23	17.35
Oder at Küstrin.........	1778-1835 (58 years)..	9.73	10.43	+ 1.61	16.75	17.97
Vistula at Marienwerder.	1809-1871 (63 years)..	28.48	16.99	- 1.63	45.21	26.98
Danube at Vienna......	1826-1871 (46 years)..	5.19	8.71	-10.37	11.73	18.94
Danube at Orsova......	1840-1871 (32 years)..	15.20	18.14	-11.41	47.49	56.70

The records adduced by Wex show that the lowest and the annual stages, and therefore the discharge of the five principal rivers of central Europe, whose total basins have an area of about 586,751 square miles, have been continually decreasing during a long series of years. He ascribes the decrease of water in these rivers to the decrease in the amount of precipitation under the influence of forest destruction, increase in the area of tilled land, and increase in the consumption of water by the increased population. Wex's book, which appeared in western Europe at the time when the flood of 1872 was still fresh in the memory, and while the country was experiencing a severe drought, made a deep impression and aroused great interest, although his conclusions in the light of more recent investigations are no longer tenable. While the fact of a general lowering of the water level of the main European rivers could not be established, there was almost a unanimous opinion that the regimen of the European rivers had undergone a considerable change. This is the attitude which has been taken by the Imperial Academy of Sciences at St. Petersburg, the Royal Academy of Sciences at Copenhagen, by the Society of Austrian Engineers and Architects, and by such prominent scientific men as Markham, Hahn, Wanger, Humboldt, Berghaus, Ebermayer, Grollger, and Branders in Germany; Colvert, Arago, Malte-Brum, Dumas, and Becquerel in France; Herschel, Dove, Glaisher, Milne-Holne, and Bergmore, in England.

The objections raised to Wex's conclusions were based on the fact that he compared the mean annual medium and low-water stages. It has been pointed out that an average river stage can not be a reliable measure of the actual discharge of the river. The water stages may decrease, yet the total discharge of the rivers may remain

the same, as when the river beds are deepened or a change in the slope caused by river improvements takes place. Therefore, even if the height of the medium and low-water stages decreases, this does not furnish reliable proof that the total discharge has also decreased. The only way to determine with certainty whether a decrease in the volume of water has taken place is to measure directly, for a long period of years, the actual discharge of rivers and streams. It has been especially emphasized that a diminished height of medium and low-water stages may be produced by an increase in the height of high-water stages, or, in other words, that the regimen of the rivers might undergo a change without a decrease in the total annual discharge. This criticism of Wex's data applies to most of our stream measurements of to-day.

Louis Torelli, in his work published in 1873, brought together observations and facts gathered in Italy of the injurious effects of clearing of forests upon streamflow. Thus, according to him, the volume of water at the lowest stage of the River Sele had decreased 33 per cent during 150 years; that of the River Brenta at Bassano, 7 per cent between 1684 and 1877; and that of the River Adda, 13 per cent between 1842 and 1862. Basilari, vice president of the board of public works, in Italy, in his report submitted to the Italian Government, in 1876, "On the Destructive Floods of the River Po," after a very careful hydrographic survey of the whole valley, came to the conclusion that the floods of the river had constantly increased in height, especially during the last century, and that one means by which the height of these floods could be diminished, or at least the increase stopped, was suitable laws prohibiting the destruction of forests.

Such a noted meteorologist as Prof. Ebermayer, after a careful study of the different effects of the forest, pointed out in 1873 that the wealth of forests and the water supply of a country are closely bound together; that springs and creeks dry up the flow only periodically; that the mean stages of rivers and creeks diminish in height when large clearings are made in the forest; and that, on the other hand, springs flow more copiously and regularly when new trees are planted and forests are increased in extent.

Europe abounds in many historic proofs of the influence of forests in regulating streamflow. The rivers Durance and the Seine were navigable at the time of the Roman rule in France, while at present, their watersheds having been cleared of forests, the Durance can hardly float a skiff in summer, and the Seine, in which the difference between high and low water stages is now over 32 feet, was only made navigable again by the construction of numerous wind dams.

The Loire was formerly a navigable river of the highest order, which afforded sure communication between Nantes and the central provinces. In 1551 the Marquis of Northumberland, ambassador from England, went from Orleans to Nantes "with his suite in five large, many-cabined boats." Now navigation on the Loire above Saumur is impossible. The bed of the river has risen enormously because of the large volume of detritus, brought from the mountains of the central plateau, that it carries with every flood. The remains of Roman villas recently discovered on the shores of the river are several feet lower than the present level of the river.

Forests cover hardly 13 per cent of the area of the drainage basin of the Loire, which is composed of impermeable ground. The many

denuded slopes are favorable to surface run-off. On account of deforestation the Loire is in summer nothing but a great stretch of sand. When a storm comes, or a sudden thaw in winter, or prolonged rains in autumn "every depression of the ground gathers a torrent, every ravine confines a river, and all these waters, accumulating in the valley of the Loire, form a roaring sea which reminds one of the great rivers of America."[1] At Roanne the flow at low water and the flow at times of flood is in the ratio of 1 to 1,458. Five days are sufficient to restore the almost dried-up river and to raise the water level to 20 or 23 feet.

In Russia the noted meteorologist, Woeikov, from the records collected on the River Volga, the largest river in Europe, for the period between 1828-1868, computed the changes which took place in the length of time, first, between the opening of the river and the beginning of high water; second, between the opening and the maximum flow of the river; third, between the opening of the river and its normal flow; and fourth, the changes in the maximum river stages. He computed his data by decades and came to the conclusion that high waters in the latter part of the period under observation began earlier than in the 40's. The duration of the high-water stage had become longer and the height of the spring floods had increased. He attributed this change in the regimen of the river to the destruction of the forests upon its watershed.

Records of Rivers in British India.

In British India there are many reliable records of changes in the regimen of the rivers because of the destruction of forests. In Bengal the Rivers Koina and Rora, in Singhbhum, both 30 to 45 miles in length, clearly show the influence of forest cover upon streamflow. The River Koina drains a tract of country of which 80 per cent is reserved forest and holds a plentiful supply of water throughout the year. The River Rora flows through country almost entirely denuded of forests. Its waters run very low even in the cold weather, while in the hot weather it dwindles away to nothing.

Another striking instance of the influence of forest growth upon the flow of a stream is furnished by Popa Hill in the Myingyan district, Burma. Before the present Popa reserve was formed and the clearing of the hillsides prohibited, the stream which runs by Popa village gave a very precarious supply of water in the dry season, and one year it completely dried up, with the result that the village and the military police post had to be temporarily abandoned. Since the forests on Popa Hill have been reserved and protected from fire, there has always been an abundance of water in the springs during the dry season of the year.

In 1908 an influential committee was appointed in British India to examine the question of denudation of forests in Chota Nagpur and Orissa. The committee considered it proved that streams in Government reserves last longer through the hot weather than streams of the same size in a denuded area, and was so convinced of the importance of preserving the forest that it drafted a bill which is now

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[1] Castle, M. A., tr. The effect of the forest upon waters. (American forestry, 1910, v. 16, pp. 156-178.)

under consideration, giving the Government power to insist on the protection of forest growth or reforestation on waste lands not the property of the Government.[1]

Records at the Swiss Central Experiment Station.

The most careful and conclusive evidence of the influence of forest upon the regularity of streamflow is furnished by the Swiss Central Experiment Station. Experiments have now been carried on there for 11 years, or since 1890, and are confined to two watersheds located in the valley of the River Emme. In order to eliminate many of the counteracting factors which are found on large drainage basins, the Swiss Experiment Station selected for its study similar watersheds, one with an area of about 140 acres, the other about 175 acres. The two watersheds are as similar in topography, geological formation, soil, and latitude as could be found. The only difference is that one of them is completely wooded (98 per cent), the other is only partially wooded (30 per cent). Accurate measurements of rainfall, snow, run-off, and temperatures are carried on by means of ordinary and self-registering instruments. The two streams are measured continuously by a self-recording instrument installed by the Hydrographic Institute of Switzerland.

The final results of this experiment are not yet published, since the aim is to include records of excessively dry and wet years. So far the station has secured records for extremely dry years, but no records of exceptionally wet ones. The preliminary report made by Prof. Engler at the International Association of Forest Experiment Stations in 1906 shows, first, that at the time of the maximum of high water the channel of the deforested region carries from 30 to 50 per cent more water per unit of surface than the wooded region; second, that after prolonged dry periods the springs of the deforested region dry up completely, and the bed of the stream is dry, while the stream from the wooded valley is still yielding at least 5 liters of water per second; third, that the forest performs the beneficial function of equalizing the flow through the year in dry and wet periods without diminishing the total yearly discharge of the streams; in other words, that the amount of water discharged by the two streams during the year is about the same.

Report of the Tenth Congress of Navigation.

The views held by the hydrographic engineers of Europe were fully expressed at the Tenth Congress of the Permanent International Association of Navigation, at Milan, in 1905. One of the subquestions considered at this congress was the influence which the destruction of forests and the drainage of marshes has upon the regimen and discharge of rivers. Seven reports upon this question were submitted, six of which were summarized in a general report.[2]

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[1] Influence of forests on drought. (Indian Forester, 1911, v. 37, pp. 477–489.)

[2] The seven individual reports were by: Mr. H. Keller, privy councillor, department of public works, Austria; Mr. H. N. R. Lafosse, inspector of rivers and forests, France; Mr. V. Lokhtine, engineer, Russia; Mr. Ponti, chief engineer of the Genio Civile, Italy; Mr. J. Riedel, engineer, technical councillor at Vienna, Austria; Mr. J. Wolfschütz, agricultural councillor in Brünn, Austria; Mr. E. Lauda, engineer, senior councillor of construction, etc., of the Hydrographic Office, Vienna, Austria.

The general report, which failed to consider Mr. E. Lauda's paper, was prepared by Mr. Cesare Cipoletti, an Italian engineer.

The general report shows that the engineers were unanimous upon the following points:

1. Forests increase the mean low-water levels of rivers and make their flow more uniform at ordinary stages.

2. When situated on impermeable soils and on slopes, forests form and maintain springs.

3. Forests hold the soil on slopes and so prevent destructive erosion and its consequences.

Regarding impermeable soils, the engineers were agreed (except the representative from Austria) that forests facilitate the storage of water by the soil, and are therefore favorable to the formation and maintenance of springs. None of the engineers denied the advantageous influence of forests upon streamflow during the low-water, high-water, and ordinary flood stages.

One of the engineers representing Austria, Mr. Keller, held the opinion that arable lands must be considered to be more favorable for the replenishment of subsoil water than forests are, but in connection with this conclusion he advanced an argument which is of the utmost importance in any public-land policy. Arable land, he contended, retains its water-storing capacity only when it is worked under scientific systems of agriculture. Since it is always doubtful whether such systems will be applied and continued, deforestation implies a menace to the storage capacity of the soil. He points to Asia Minor and to many Provinces of southern Italy which were formerly rich and flourishing, but are now arid and waste, and ascribes the deterioration not to deforestation, but to the decay of agriculture.

The chief engineer of the Genio Civille, Italy, drew a radical distinction between permeable and impermeable soils. On impermeable soils the forest cover, by allowing the rainfall to drip slowly to the ground and by preventing its rapid surface run-off, induces the water to sink gradually into the ground. He cited numerous instances in Sardinia, the basin of the Adda, the Province of Benevento, and other places in Italy, where all springs on impermeable soils disappeared after the forests had been destroyed. On highly permeable soil, however, he did not attribute to the forests any effect upon the storage of ground water. On the contrary, he held that forests on such soils may be even detrimental to direct absorption of water, as in the case of fissured or porous limestones. Thus, on the permeable limestone he claimed that from 75 to 80 per cent of the rainfall is absorbed by the soil directly, an amount which could not be absorbed by any vegetative cover.

All the engineers, without distinction, admitted that the deforestation of sloping lands, unless the lands are afterwards kept under some substitute cover of equal efficiency, causes erosion, and in many places landslides and avalanches. This conclusion was reached both directly and indirectly. It was supported both by positive and negative evidence. Thus, the enormous damage by erosion which followed deforestation in Sardinia and other Italian Provinces was noted by Ponti and others, while Lafosse pointed to the marked improvement which has taken place in the regimen of rivers in France since the State has successfully reforested several million acres in their catchment basins.

It was pointed out that damage from erosion is most severe in small and narrow basins and where the subsoil is impermeable. Landslides and avalanches are most likely to occur where the forest is removed from ground that is marly, sandy, or composed of fibrous rocks. The damage will be less serious if the cleared land is left as a meadow and is not broken up with the plow, or if steep slopes are eased off by terraces, or if the speed and force of the run-off is broken by contour ditches, such as the so-called "gira-monti" in Italy. At the same time such artificial aids may not prove efficacious. Their construction and maintenance are as a rule costly, and they may not be used at all; or if used, may be neglected, and in that case the logical effect of deforestation will make itself felt in the land waste which Keller points out has followed the decay of agriculture in regions that have been thus abused.

Total Discharge of Streams.

In discussing the relation of forests to streamflow a clear distinction must be made between total annual discharge of a river, or average annual discharge, based upon observations for a number of years, and the actual behavior of the stream during the different seasons of the year. The total discharge of a river, or its average annual discharge, or its average annual stages may remain the same throughout a series of years, yet its regimen may be so changed that its usefulness is greatly impaired either for water power or navigation. It is very necessary to keep in mind that the average height of a river is not a reliable measure of its actual average annual discharge or of its total discharge. The average annual river stages may remain the same, yet the average annual discharge may increase or decrease, or vice versa.

Thus Ule,[1] from an actual comparison of the water stages and the flow of water in the River Saale for March, 1896, has shown that while on the basis of the mean water stage the flow was computed on 378,000,000 cubic meters, the daily measurements gave 508,000,000 cubic meters, or 34 per cent more. The mean water stage in March was 2.13 meters, and in December 2.15 meters, yet the amount of flow in the month of March was 23 per cent smaller than in December. These figures show how unreliable are the readings of average river stages for determining the actual discharge of the rivers. If the flow of water in a stream is compared with the precipitation over its watershed for a number of years, there will be found a similarity between the fluctuation in the flow of water and that of the precipitation. On the whole, the amount of water carried by a river depends upon precipitation and temperature. It is greater when the temperature is low, though the precipitation is scant, than during years of greater precipitation but of higher temperature. Large rivers are least affected by climatic fluctuations, because their large watersheds exercise an equalizing influence upon the ununiform distribution of precipitation. That the flow of water in streams depends largely upon climate is now a fact accepted by meteorologists, engineers, and foresters, and is supported by very careful observations on a number of rivers, especially in Europe.

[1] Ule, W. Theoretische Betrachtungen über den Abfluss des Regenwassers. (Zeitschrift für Gewässerkunde, 1905, v. 7, 65–86.)

The geologist and hydrographic engineer, Dr. Penck,[1] has, more than anyone else, been instrumental in showing, by actual measurements of streamflow, precipitation, and evaporation, the dependence of the total amount of water carried by rivers upon precipitation and temperature. His studies of the River Danube, and especially of the Elbe, led him to the conclusion that the rivers of central Europe depend for their flow upon precipitation. He found that the total run-off in the rivers of central Europe forms about seven-tenths of the precipitation above a certain minimum (16.38 inches). If precipitation fell below this minimum no water would be available for stream flow. Practically the same thing has been found to be true by F. H. Newell[2] for the run-off of North American rivers. Here the minimum of precipitation below which no run-off would take place is 11.7 inches. Of the precipitation remaining above this minimum eight-tenths runs off into the rivers. In order to show the relation between total run-off and precipitation, Newell used two maps, one showing the total run-off from land in the various large divisions of the country and the other the mean annual precipitation. The run-off has been expressed by depth in inches over the whole catchment basin. While the two maps do not coincide exactly, yet there is a close similarity between the depth of run-off and the mean precipitation. Thus in the central regions of the United States, where the run-off ranges from 0 to 2 inches, it forms 10 per cent of the precipitation; where the run-off is from 2 to 5 inches, from 10 to 25 per cent; where it is from 5 to 10 inches, from 40 to 50 per cent; and, finally, where the run-off is 20 inches and over it represents over 50 per cent of the rainfall. This relation between total run-off and precipitation, modified by topography, shows clearly that the total amount of water in the rivers depends first of all upon the climate of the region. Similarly, a German engineer, Scheck, has shown that the per cent of run-off in the European rivers decreases from west to east (in accordance with the decrease in precipitation), from 0.4 for the Rhine to 0.2 for the Memmel.

The rivers of a country, therefore, are the result of the climate, and fluctuations in the total amount of water carried by them must depend upon climatic fluctuation. Without a general change in the climate there can be no general decrease of water in large rivers.

Prof. Brückner, from a mass of evidence collected by him, has shown that there exist climatic cycles with cool and humid, and dry and hot years, and that the variation in the yearly discharge of rivers must be attributed to the climatic fluctuations. Thus, according to Brückner, in Europe the periods between 1806–1815, 1841–1855, and 1871–1875 were humid and cool, and the highest water in the rivers occurred in 1815 and in the five-year periods between 1846–1850 and 1876–1880. The periods between 1820–1840 and 1856–1870 were warm and dry, and the water during the five-year periods between 1831–1835 and 1861–1865 was at its minimum. The presence or absence of forests, therefore, can have no influence upon the mean annual flow of water in large rivers.

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[1] Penck, A. Die Flusskunde als ein Zweig der physikalischen Geographie. (Zeitschrift für Gewässerkunder, 1898, v. 1, p. 4.)

[2] Newell, F. H. Results of stream measurements. (U. S.—Geological survey. 14th annual report, 1892–93, pt. 2, pp. 89–155.)

In many quarters there exists an impression that foresters claim that wooded watersheds have an effect upon the total yearly discharge of water in streams, and that with the destruction of the forest the total discharge or the average annual discharge of water must inevitably decrease. As a matter of fact, foresters have never made any such claim. On the contrary they were the first to point out the possibility, under certain conditions—for instance, in a semiarid region—of a wooded watershed consuming a larger amount of water than a bare watershed or one covered with low vegetation, and in this way diminishing the total amount of water available for streamflow during the year.[1]

Any figures, therefore, which show that the average annual water stages or actual average annual discharge of water in a stream remain the same, irrespective of change in the surface cover of the watershed, do not prove in any way that a forest has no influence on the behavior or the regularity of the flow of water in streams.

SEASONAL VARIATION OF STREAMFLOW.

While precipitation is responsible for the amount of water in the streams, the relation between precipitation and the river stages during the year is not direct or immediate. Prof. D. W. Mead,[2] in his study of the Wisconsin rivers, points out that rainfalls of 3 or more inches per month during the early portions of the year give rise to a flow of considerable magnitude, whereas even greater rainfalls during the summer months have little or no effect in augmenting the flow of the stream. During the period between December and May the winter snow and the spring rains saturate the ground. This is the storage period. During June, July, and August the rainfall is rarely sufficient to take care of evaporation and plant life, and the streamflow is therefore usually dependent entirely on the ground water. The ground water begins to furnish more or less of the stream flow as early as May. Prof. Penck found, for the Elbe, that during the months of August, September, October, November, December, and January there is going on a storage of water in the form of snow and underground waters, while in the months of February, March, April, May, and June the stored water is gradually fed out and sustains the flow of water in the river.

From a table worked up by him for the Elbe, it follows that if there was no storage of water in the form of snow and underground water during the period between the months of August and January the discharge of the river in April would be near zero, and in May it would stop flowing entirely. By actual measurements of the discharge of water in the Elbe and of the precipitation over and evaporation from its watershed for 15 years, Penck found that one-third of the total precipitation goes into the river. Of this one-third, two-thirds reach the river as surface run-off and the remaining one-third, or one-ninth of the total precipitation, reaches the river as underground water. The highest stages during the early spring are the direct consequence of the accumulation of underground waters dur-

[1] Toumey, James A. The relation of forests to streamflow. (U. S.—Dept. of agriculture. Yearbook, 1903, pp. 279–288.)
[2] Mead, D. W. The flow of streams and the factors that modify it, with special reference to Wisconsin conditions. (University of Wisconsin. Bull. 425, 1911.)

ing the fall and winter. The accumulated underground water is gradually fed out during the early summer. It is evident, therefore, that if the total amount of water carried by the river during the entire year depends upon the amount of precipitation, the amount of water carried by a stream during the different seasons of the year depends upon the storage capacity of the watershed, whether the storm waters reach the river as soon as they fall or are retarded in their flow and reach the river as underground seepage at a time when precipitation is lacking or scant. The flow of water in the stream during the summer is sustained by the underground water stored at the time of excessive precipitation.

FORESTS AND SPRINGS.

The forest cover, among other factors, affects the storage capacity of a watershed and is instrumental in sustaining the flow of water in rivers at times when precipitation is lacking or is just sufficient to cover evaporation.

The effect of forest cover upon the sustaining of springs and the flow of water during the dry part of the year is well brought out in the annual report of the State geologist[1] of New Jersey for the year 1899. A comparison of the amount of water, expressed in inches of rainfall, that reaches streams through underground seepage from forested, cultivated, and barren watersheds during a dry period, when the rainfall is equal to the evaporation, and, therefore, the effect upon streams is eliminated, give the results shown in Table 21.

TABLE 21.—*Yield of springs on forested, cultivated, and barren watersheds during drought.*

Month.	Forested watershed, Passaic.	Cultivated watershed, Raritan.	Barren watershed.
First month	1.16	1.43	0.94
Second month	.54	.64	.38
Third month	.40	.45	.26
Fourth month	.33	.35	.20
Fifth month	.32	.30	.14
Sixth month	.31	.27	.12
Seventh month	.30	.25	.10
Eighth month	.29	.23	.08
Ninth month	.28	.22	.07
Total	3.93	4.14	2.29

These figures, which are the result of computation based upon actual gaugings, show that while the cultivated and forested watersheds yield almost the same amount, the cultivated watershed gives off its water faster during the first months, and therefore, sooner becomes exhausted. The barren watershed, whose underground storage capacity is small, has little flow for springs, which almost dry out toward the end of the drought.

Europe abounds in authentic historic records of the disappearance of springs as a result of deforestation. Edward Ney,[2] forester and

[1] Vermeule, C. C. Forests and Water Supply. (New Jersey—Geological survey. Annual report, 1899, p. 162.)

[2] Ney, E. Ueber den Einfluss des Waldes auf die Bewohnbarkeit der Länder. Prag, 1875.

hydrographer, of Alsace, in a paper published in 1875, mentioned that in the Provence, after all the olive trees, which there formed regular forests, and which were frozen in 1822, had been cut down, a great number of springs failed entirely, and that in the city of Orleans, after the surrounding heights had thus been cleared, nearly all the wells dried up, making it necessary to conduct the headwaters of the river Little Loire into the city.

A Swiss engineer and hydraulic expert, Robert Lauterburg,[1] who collected a large number of exact data relative to the discharge of rivers in Switzerland, found, on the basis of accurate measurements of the discharge of springs, that in the Melasse formation, within an area of 0.29 of a square mile, the springs in wooded portions discharge from 5 to 10 times more water than those in the clearings.

The springs of Bresle dried up about 1840, after clearing off a forest of some importance situated in the parish of Formerie (Oise). Soon after the forest of Cressy was cut in 1837 the source of the Arrivaux River descended toward Breuil (Somme) one kilometer. Clearings made in the forest of Arronaise were injurious to all the streams that flowed from it to Escaut and Somme.

After the death of Don Bouthillier de Rancé the abbe of la Trappe leased the iron works connected with the monastery to private parties for 12 years. It was necessary, according to the biography of Don Pierre the Dwarf, subprior of the monastery, " to destroy the forests of la Trappe in order to maintain the furnace fires, and it is impossible to tell how far-reaching the effects were. The springs soon dried up and the ponds yielded water only six weeks in the whole year." This was written in 1715.[2]

Near the little village of Orgelet (Jura), at the foot of the east slope of the Orgier Mountain, in the parish of Plaisia, there is a spring called the Fountain of Plaisia, which disappeared during the entire time that the mountain remained cleared of its forests (from the end of the eighteenth century to the middle of the nineteenth), and reappeared 30 years ago, when the work of reforesting the slope had been finished. Numerous inhabitants of the country testify to this fact.

According to the testimony of the mayor of Flacey (Côte d Or), the spring supplying this village had always had a constant and regular flow as long as the limestone uplands, from the foot of which it issued, remained covered with a coppice of vigorous oak over an area of 100 hectares. At the beginning of the nineteenth century, the area having been deforested, the spring no longer had a regular flow, and was entirely dry the greater part of the time.[3]

De Rothenbach, director of the water service of the city of Berne, made observations on the flow of the springs of that city. Expressing the minimum as 1, the flow per minute of two of them, the Schliern and the Gasel, varied from 1 to 2.7 and from 1 to 4.1, respectively, while the variation of a third spring, that of Scherli, was from 1 to 6.7. The basin of the springs of Gasel and Schliern is

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[1] Lauterburg, R. Ueber den Einfluss der Wälder auf die Quellen und Stromverhältnisse der Schweiz. Bern, 1875.

[2] Mr. E. Charlemagne has given an instance to the point in the Revue des Eaux et Forêts of the disastrous effects that the heedless cutting of forests may have upon streamflow.

[3] Mathey, A. Influence des Forêts sur le débit et la régularité des sources. (Revue des eaux et forêts, 1898, v. 37, pp. 561–563.)

sheltered by a considerable mass of forests, while that of Scherli comes from a mountain partly deforested. Other observations tended further to show that the forest, during dry times, gave out slowly the water it had stored up during a rainy period. Thus during the summer of 1893, which was marked by a long and destructive dry period, the spring of Scherli reached its smallest flow September 3, 1893; but that of Gasel not until three and a half months later, and that of Schliern six and a half months later.

In Algeria the trees disappeared and the springs dried up. In the Canton of Bouffarik, formerly noted for its rich water supply, 15 springs decreased in two years from 1,316 to 710 liters; rivers such as the Oued Chemla, which had a flow in 1864 of 150 to 180 liters, no longer yield more than from 70 to 80 liters; the Oued Kremis, which had a flow in 1864 of from 100 to 200 liters, in 1881 had a flow of only 15 liters. The water supply of cities like Saint-Denis-du-Sig disappeared, and water was shipped in over the railways. The water in the canals of the city of Algiers diminished from year to year. At the gates of the city a striking example of the dearth of water can be observed. Thirty years ago the Oued M'Kacel, in its cool valley, had the power to turn four mills; to-day water and mills have disappeared with the forest that covered Mount Bouzarea.

The eminent geographer, Onesimé Reclus, cited the example of the city of Tunis, which was formerly supplied with pure water from the springs issuing from Mount Zaghouan, springs that have disappeared since the mountain was deforested.

The flow of the streams diminished notably at Martinique after the island was deforested for charcoal. In the same way water in the canal built in 1867 by Admiral de Gueydon to convey good water to Fort-de-France diminished considerably, and the government of the colony has very recently adopted measures to check the deforestation.

Mr. Crahay, inspector of waters and forests at Brussels, noticed at Planchimont that the flow from the springs of La Sure became more regular after the region has been reforested with spruce for 40 years. "One of them," he wrote, "that gave no water during the summer, never dries up now, and issues 70 meters higher on the slope than did the former spring. At Bois-le-François, parish of Villiers-devant-Orval, after the clearing of an old coppice forest, two springs disappeared. The place where the water issued and the little channel that it followed down the slope can still be seen."

At the International Congress of Silviculture, held at Paris on the occasion of the exposition of 1910, Grebe, forester councilor at Eisenbach (Alsace), cited numerous examples of springs that had dried up or of diminutions in streamflow noticed after deforestation in central Germany. He told also of cases where springs reappeared after reforestation had taken place. Another German forester, M. B. A. Bargmann, told of the disappearance of two springs in the valley on St. Amarin (Alsace) after clearings had been made above them.

At the same congress Mr. Servier, a landholder at Lamure-sur-Azergues (Rhone), gave several interesting facts. In the region in which he lives, which until late years was almost completely deforested, he noticed that wherever a cluster of trees remained their presence was coincident with the existence of a spring. The flow

of a spring on the western outskirts of a coppice wood diminished continually after the coppice had been cut, but returned to normal when the coppice grew up again.

An inquiry into the influence of forest cover upon springs, made by the National Conservation Commission in the fall of 1908 among foresters and engineers throughout the country, revealed a remarkable unanimity of opinion on this point, and brought to light numerous instances of the drying up of springs as a result of forest destruction.

"Springs near Odessa, N. Y., have had their flow decreased 50 per cent as a result of forest destruction." (H. A. Paine, Denton, Md.)

"Streams are lower in every case in Vermont where the virgin timber has been cut, and new growth does not help this condition until it gets large enough to completely cover the ground and high enough to afford perfect shade and admit circulation of air under the branches." (H. D. Packer, West Burke, Vt.)

"Capt. Miller, an old settler in Alamogordo, N. Mex., states that a large spring at the head of the La Luz Canyon dried up after logging at its watershed in 1899." (A. M. Neal, Alamo National Forest, Alamogordo, N. Mex.)

"In north Georgia it has been noticed that in many cases streams have perceptibly lessened in flow since the destruction of the forest. In many cases large streams have dried up." (S. W. McCallie, Geological Survey of Georgia, Atlanta, Ga.)

"At Truckee Ranger Station, Tahoe National Forest, is a spring never known to go dry before July, 1908. The timber has been almost entirely removed from the watershed and the snowfall is also much less than in former years. In another part of the Forest is a spring which flowed throughout the year previous to the removal of the timber in 1902. In August, 1905, the spring contained some water, but none was flowing on the surface of the ground. Still another spring is now dry about 3 months in the year, whereas previous to the removal of the timber 10 years ago it was never known to go dry." (M. B. Pratt, Tahoe National Forest, Nevada City, Cal.)

"Glens Spring, near Fremont, Ohio, in 1879 had a daily discharge of 35,000 gallons. It is now reduced to less than 1,000. Muscalounge Spring has had its flow reduced from 140,000 to 2,000 gallons. Numerous other springs near Fremont which flowed profusely before 1890 have now dried up completely, undoubtedly due to deforestation." (C. O. Lasley, Fremont, Ohio.)

"Flow of streams on Big Pryor Mountain have diminished greatly in the last 5 years, and many have dried up entirely in July. Forest of lodge-pole pine was removed." (V. G. Langtry, jr., Absaroka National Forest, Livingston, Mont.)

"Several small springs east of Marysvale, Utah, previous to 1901 had sufficient flow to water large herds of cattle and maintain a steady flow. Since then overstocking of range and removing grass covering have caused the springs to dry up, until they are of practically no use." (C. S. Jarvis, 33 East Second Street, South Provo, Utah.)

"All springs in the Manti National Forest now flow more freely than ever before the creation of the Forest. The formation is limestone. The forest cover has now returned." (A. E. Jensen, Manti National Forest, Ephraim, Utah.)

"In Stonelick Township, Ohio, there was a spring which during the Civil War flowed regularly and freely, but has now ceased to flow. It is located at the foot of a high hill on which the timber has been cut and which may be the cause of the stoppage in the flow of water." (G. H. Hill, box 26, Milford, Clermont County, Ohio.)

"Spring Gulch, near Providence, Ariz., had always had a steady flow until the timber surrounding it was cut, when the water ceased to flow during the dry months." (J. D. Guthrie, Prescott National Forest, Prescott, Ariz.)

"The cutting of forests in Newport, Ky., has resulted in drying up of springs which old residents say used to flow throughout the year." (W. L. Glazier, Newport, Ky.)

"Numerous springs in Pike National Forest have dried up as a result of cutting timber. One spring in particular which flowed throughout the year for 30 years entirely dried up after clearing the timber from 360 acres about it.

"On the west branch of Michigan Creek, Colo., several streams which previously flowed all the time are now dry as the result of cutting.

"Since the severe fire in Calahan Gulch, Pike National Forest, Colo., several springs have entirely dried up." (C. W. Fitzgerald, Pike National Forest, Denver, Colo.)

"In Caribou, Me., is a spring which in 1880 was large enough to be used as part of the water supply of the village. Since the cutting of the forests on its watershed its flow has materially decreased, and in 1904 was practically dry." (A. C. Hardison, Santa Paula, Me.)

"Many years ago the springs near Iowa City, Iowa, flowed throughout the year. Since the cutting of the timber they have entirely dried up." (Clark R. Fickes, C., B., & Q. R. R., Chicago, Ill.)

"Many springs near Meadville, Pa., have been dried out in recent years, and many wells are much deeper than formerly, due to deforestation." (W. A. Doane, Meadville, Pa.)

"Since the cutting away of the timber on the hillsides near Leadville numerous springs which flowed all the time have dried up and the snow melts much earlier in the spring." (J. W. Deen, Denver & Rio Grande Ry. Co., Salida, Colo.)

"Springs near Wilmington, Mass., dried up as a result of cutting pine forests. Where these were cut 20 to 30 years ago springs have begun to flow again." (W. W. Cummings, Boston, Mass.)

The most direct evidence, however, of the effect of extensive clearing upon ground water has been recently brought out by Dr. W J McGee.[1] During a period of about 22 years 9,507 wells in the States of Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Ohio, Tennessee, and Wisconsin show a lowering of the water table at a minimum mean rate of 1.315 feet, or, with moderate allowance for new wells, 1.73 feet, per decade, corresponding to a total of 13.8 feet for the 80 years since settlement began. The loss, according to Dr. McGee, is due largely to increased run-off in freshets and floods, which are in increasing degree wreaking destruction of property and loss of life, while innumerable springs and smaller-source streams have disappeared, and the regimen of nearly all streams has been impaired.

[1] McGee, W J. Principles of water-power development. (Science, Dec. 15, 1911, pp. 813–25.)

These facts tend to show that there is a most intimate relation between forest cover and underground water, and as the continuity of streamflow depends wholly upon the water stored in the ground, the effect of forests upon the regularity of streamflow becomes evident.

FORESTS AND FLOODS.

High floods are caused in large navigable rivers either by excessively heavy or by long-continued rains. During the first hours of heavy rainfall, and often during the precipitation which may precede it, the forest floor becomes so completely saturated with water that it allows any further rain to pass off just as it would from open ground. The influence of the forest on the prevention of catastrophes from high water and floods is therefore limited. The forest can prevent smaller floods by retaining a certain amount of water and retarding the flow, but it is powerless to prevent greater ones. The latter are the result usually of either a large quantity of rain falling on frozen or saturated ground covered with snow, especially in late winter, or an unusual amount of rainfall, even for a short period, in the territory drained.

Since the amount of water which the forested soil can absorb or retain is small as compared with the amount which it receives during a downpour, or with a sudden thaw, it is evident that under exceptional meteorological conditions the retentive capacity of the forest floor must fail. Forests can absorb a quantity of water corresponding to a precipitation of 0.16 of an inch, or, in very favorable conditions, of 0.24 of an inch. According to Bühler, the highest amount beech foliage can absorb is 18,000 liters per hectare (7,200 liters per acre) and moss 24,000 liters per acre, corresponding to a precipitation of 0.07 and 0.24 inch, respectively. Ebermayer estimates that dry litter in beech forests absorbs an amount equal to 0.09, in pine forests 0.05, and in spruce forests about 0.05 inch of precipitation. Ney's results give 0.09 inch for beech forests, 0.15 inch for pine, and 0.07 inch for spruce. According to Riegler, the water absorption by moss amounts to from 200 to 900 per cent of its weight; with foliage it equals 150 to 220 per cent; and with pine needles 120 to 134 per cent. According to Gerwig, moss can absorb from 0.18 to 0.39 inch of water.

In comparison with these amounts the quantities of water that cause excessive floods are enormous. On March 6, 1896, there fell on the Kniebis in the Schwarzwald 7 inches of rain; in three days (from 6th to 8th of March), 13 inches (flooding of the Dreysam Valley); in Eichberg, Silesia, July 29, 1897, 4.4 inches; from July 28 to 30, 6 inches; on the ridge of the Riesen-Gebirge, July 30 and 31, 8.8 inches (flooding of the Hirschberg Valley); in Munich, September 13, 1899, 3 inches (destruction of the Prinz-Regent Bridge); in the Bavarian Mountains, more than 4 inches.

In Austria, at the time of the high-water catastrophe in July, 1897, in the course of two days, in the Unter Inns district, there was a rainfall of 5.8 inches; in the Traun district, 7.4; and in Vienna, 6.9 inches. In September, 1899, in the course of two days in the Salzach district, the rainfall amounted to 6.7; in the Traun district, 8.3; at Enns, 7.8; at Ybbs, 8.3; and at Trausen, 6.6 inches. From July 26 to 31 (six days),

1897, in the territory of the Donau River, there was a rainfall of 421,768,000,000 cubic meters; and in September, 1899, within seven days, 565,024,000,000 cubic feet. The total of this land ocean amounted to 1,412,560,000,000 cubic feet.

While the forest is necessarily helpless to prevent the occurrence of excessive floods during periods of exceptional rainfall, yet by protecting the soil against erosion, by diminishing the proportion of detritus carried by the run-off, and by absorbing at least part of the water that falls upon the ground, it has a mitigating influence even on the highest floods. The fact that the volume of eroded matter carried by the streams in periods of flood is greatly diminished by the presence of the forest must necessarily decrease the violence of the floods, since sand, gravel, pebbles, and rocks torn from the soil by the stream raise the level of the stream beds and increase the volume of water carried.

There is no lack of facts to establish this moderating action of the forest. Marchand gives an example of a torrent in the canton of Appenzell, Switzerland, which formerly became swollen at Weissenbach about three hours after the storms had burst upon the mountain. Following a partial deforestation of the mountain, the floods became manifest at Weissenbach within one hour after the appearance of storms. The presence of the forest, then, had the effect of delaying by two hours the manifestation of flood and of increasing by four hours the duration of the run-off.

Many streams that descend from the departments of the Vosges Mountains, which still bear a large forest cover, do not have as frequent nor as disastrous floods as the torrents that come down the denuded slopes of the Alps, or the streams of irregular flow that issue from the deforested Cevennes (Ardeche, Lot, Tarn, Dourbie, Loire, Allier), or from the waste lands of the Central Plateau (Cher, Sioule, Creuse). The proportion of forest area of the Vosges is 35 per cent, while that of the Alps of Savoy is 21 per cent, that of the Alps of Dauphiny (Isere, Drome, and Hautes-Alpes) 13 per cent, that of the Alps of Provence (the Lower Alps and Maritime Alps) 12 per cent, and that of the Central Plateau and of the Cevennes 12.2 per cent.

In the Department of Aude, in France, there occurred, on September 12, 1893, a terrific storm, which caused considerable damage throughout the whole region. All the tributaries of the River Aude experienced sudden floods, and that river rose 16 feet at St. Marcel. The storm lasted an hour and a half, and there was a rainfall of 2.4 inches. The Blanque River, which unites with the Salz 5.6 miles above Couiza, and which, like it, flows down slopes almost entirely denuded, immediately rose 3 feet and devastated a large amount of property along the river, especially at Rennes-les-Bains. At Couiza the flood was greater, and the frightened inhabitants feared a repetition of the disasters of 1891. In the basin of the Rialsesse, which flows into the Salz 3.6 miles above Couiza, the amount of the rainfall was 2.4 inches also. This river, however, did not overflow nor cause any damage. In contrast to the denuded slopes down which poured the run-off into the Salz and the Blanque was the heavily wooded basin of the Rialsesse, where, to supplement the existing cover, 4,200 acres had been reforested.

At the International Congress of Navigation, in 1905, Cipoletti, an Italian engineer, who prepared the general report embodying the views of the engineers representing the different countries at the Congress, maintained that while it is true that during a prolonged rain a moment is at last reached when the run-off to the valley is equal in amount to the rainfall in the forest above, it does not follow by any means that this moment coincides exactly with the moment of the heaviest rainfall. In every instance he found that the balance between run-off and rainfall was reached only when the rain had begun to abate; in other words, the moderating influence of the forest upon run-off continued to act during the critical period, and that without this influence the floods would be destructive in their effect.

In Baden the Government, after disastrous floods of the Rhine and its tributaries in 1882–83, appointed a commission composed of an officer of the central bureau for meteorology and hydrography, an officer of the engineer department, and an officer of the forest department to investigate the relation of forests to floods. This commission, after a most detailed survey which comprised not only the geographic, climatic, and geognostic conditions of the watershed, but more especially its surface cover, submitted a number of conclusions.[1]

1. The forest cover retards the surface run-off. It retards also the melting of the snow. In exceptional cases, however, this influence of the forest may become ineffectual, namely, during an unfavorable sequence of periods of heavy precipitation, as was the case in the catastrophe of 1882.

2. The binding of the soil by forest cover is entirely beyond dispute and, hydrographically, is of the greatest importance. The forest of the Alb watershed fulfills well its function as a protective cover. The satisfactory condition of the watercourse and valley bottoms, and the moderate extent of the damage experienced from the floods of this watershed, are due to the small amount of detritus. The soil conditions being extremely favorable to the formation of detritus and rock chutes, their absence can only be due to the forest cover on the declivities. Where masses of detritus and waste rock and landslide material were found (on about 60 acres), they could be traced to improper deforestation and pasturage.

3. While the forest could not have prevented such an extreme flood as that of 1882, yet, on the other hand, to the forest is due the fact that the Alb watershed experiences such disasters but rarely, more rarely even than adjoining valleys with a smaller proportion of forest area.

These facts tend, therefore, to show that while in the occurrence of floods, climate, character of soil, slope, and especially meteorological conditions, play the most important part, the forest cover must also be considered a factor without which the floods would be greater and more destructive. It is evident, however, that forests alone can not be depended upon to prevent the occurrence of exceptional floods, and that engineering works are necessary for the control of the flow of water in the rivers.

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[1] Fernow, B. E. Forests and floods. (Garden and forest, 1890, vol. 3, pp. 9 and 10.)

Summary of Effects of Forests Upon Streamflow.

The available observations upon the behavior of streams in this country and abroad have established the following facts:

1. The total discharge of large rivers depends upon climate, precipitation, and evaporation. The observed fluctuation in the total amount of water carried by rivers during a long period of years depends upon climatic cycles of wet and dry years.

2. The regularity of flow of rivers and streams throughout the year depends upon the storage capacity of the watershed, which feeds the stored water to the streams during the summer through underground seepage and by springs. In winter the rivers are fed directly by precipitation, which reaches them chiefly as surface run-off.

3. Among the factors, such as climate and character of the soil, which affect the storage capacity of a watershed, and therefore the regularity of streamflow, the forest plays an important part, especially on impermeable soils. The mean low stages as well as the moderately high stages in the rivers depend upon the extent of forest cover on the watersheds. The forest tends to equalize the flow throughout the year by making the low stages higher and the high stages lower.

4. Floods which are produced by exceptional meteorological conditions can not be prevented by forests, but without their mitigating influence the floods are more severe and destructive.

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Appendix VI.

THE LAW OF WATERS.

Prepared by G. W. Mooney.

Running Water the Property of No One.

Unrestrained running water, according to the civil law, is the property of no one. It is said in the Institutes of Justinian that, "By natural law these things are common to all, namely, air, running water, the sea, and as the consequence, the shores of the sea." This rule of civil law passed into the common law. Blackstone says, "But after all there are some few things which, notwithstanding the general introduction and continuance of property, must still unavoidably remain in common. * * * Such are the elements of light, air, and water." "For," as he further says, "a man can have no absolutely permanent property in these as he may in the earth and land, since they are of a vague and fugitive nature." Where the common law has been adopted in the United States, the same rule has been recognized. In the case of Mitchell *v.* Warner, 5 Conn., p. 519, it was said: "It is too late to enter into the legal character and quality of water; the law having been settled, time out of mind, on this subject, and remained uniform and unquestioned. Water is neither land nor tenement nor susceptible to absolute ownership. It is a movable, wandering thing, and must of necessity continue common by law of nature."

Rights of Riparian Owners.

While the corpus of running water is not a subject for private ownership and has been generally regarded, in some cases together with the bed of the stream, as belonging to the State in trust for the benefit of the people, nevertheless both the civil and the common law recognizes a proprietary right in its flow, called a usufructuary right. Justice Story, in Tyler *v.* Wilkinson, 4 Mason, p. 397, says: "But strictly speaking, he has no property in the water itself but a simple use of it while it passes along." Kent says, in 3 Conn., Margin, page 439, "He has no property in the water itself but a simple usufruct as it passes along." This usufruct right in running water is, nevertheless, limited to riparian owners; this limitation being naturally evolved because only riparian owners had access to the stream. The right is not a personal one but is attached to, and passes by conveyance of, the land, and is limited to a beneficial and reasonable use. Farnum, in his work on Water and Water Courses, section

461, says: "The rights of a riparian owner is that he is entitled to have the stream remain in place and flow as nature directs, and to make such use of the flowing water as he can make without materially interfering with the equal rights of the owners above and below him on the stream. This prevents the upper proprietor from diverting the stream, consuming the water for other than natural uses, polluting the water, or interfering with the regular, natural flow of the current to such an extent as materially to injure the lower owner; and it prevents the lower owner from throwing the water back on the land of the upper owner." In some States the fee of riparian lands runs to high-water mark, in others to low-water mark, but in the majority of cases to the thread of the stream. This, however, is not a distinction of any great importance, for in case the fee to the bed of the stream vests in the riparian owners, still the State has an easement over such bed, which for the purpose of protecting the public interest is equally as effective as its ownership in trust.

The Common-Law Rule of Riparian Rights Not Adopted in Western States.

The common-law rule of riparian rights, having been found inapplicable to the conditions existing in the Western States, has been superseded to a greater or less extent by constitutional and statutory provisions. Mr. Justice Brewer, in United States *v.* Rio Grande Dam & Irrigation Co., 174 U. S., p. 690, says:

"Although this power of changing the common-law rule as to streams within its dominion undoubtedly belongs to each State, yet two limitations must be recognized: First, that in the absence of specific authority from Congress a State can not, by its legislation, destroy the right of the United States, as the owner of lands bordering on a stream, to the continued flow of its waters, so far at least as may be necessary for the beneficial uses of the Government property; second, that it is limited by the superior power of the General Government to secure the uninterrupted navigability of all navigable streams within the limits of the United States."

The first of the above limitations is denied by the courts of Colorado and those States following the so-called Colorado doctrine; the Federal Government, as a riparian owner, being regarded as having no rights superior to any other riparian owner. The decisions of the Supreme Court of the United States have not yet fully determined whether the States are subject to this limitation, although they appear to support the view of the Colorado courts. The second limitation, being based on a constitutional grant of power to Congress, is undoubtedly the law. It would also seem reasonably well established by the opinion rendered in United States *v.* Rio Grande Dam & Irrigation Co., 174 U. S., 690, that the Federal Government might extend its sovereign control over every stream to its sources in the mountains wherever its waters eventually reach a stream, any part of which is navigable in fact; that is to say, it may very readily be established that it is essential to a complete and adequate control of navigation to regard the entire course of any stream, navigable in part, together with all its tributaries, as a unit, sovereignty over which can not be divided.

THE DOCTRINE OF PRIOR APPROPRIATION—CALIFORNIA.

The doctrine of prior appropriation grew out of the peculiar conditions existing in those States which adopted it, the common-law principle of riparian rights being deemed inapplicable to the proper development of the State and its resources. In these localities the prosecution of the mining industry was of paramount importance, and for this purpose it was necessary to divert water to places remote from riparian lands. Another characteristic condition was that the entire course of streams was usually within the public domain. In locating and taking possession of mineral deposits and in securing water for their development the pioneers necessarily became trespassers upon the public domain. Possessory rights, so called, immediately became recognized and respected in these localities. As between these early "possessors" the principle of "first in time, first in right" became an established rule, which subsequently the courts adopted. In the case of Irwin *v.* Phillips, 5 Cal., p. 140 (1855), the court says:

"Courts are bound to take notice of the political and social condition of the country which they judicially rule. In this State the larger part of the territory consists of mineral lands, nearly the whole of which are the property of the public. No right or intent of the disposition of these lands has been shown either by the United States or the State government, and, with the exception of certain State regulations, very limited in their character, a system has been permitted to grow up by the voluntary action and assent of the population, whose free and unrestrained occupation of the mineral region has been tacitly assented to by the one government and heartily encouraged by the expressed legislative policy of the other.

"If there are, as must be admitted, many things connected with this system which are crude and undigested and subject to fluctuation and dispute, there are still some which a universal sense of necessity and propriety have so firmly fixed as that they have come to be looked upon as having the force and effect of res judicata. Among these the most important are the rights of miners to be protected in the possession of their selected localities and the rights of those who, by prior appropriation, have taken the waters from their natural beds and by costly artificial works have conducted them for miles over mountains and ravines to supply the necessity of gold diggers, and without which the most important interests of the mineral region would remain without development."

After referring to certain acts of the legislature which recognized these possessory rights as of valid existence within the State, the court continues:

"This simply goes to prove what is the purpose of the argument, and however much the policy of the State, as indicated by our legislation, has conferred the privilege of working the mine, it has equally conferred the right to divert the streams from their natural channels, and as these two rights stand upon an equal footing, when they conflict they must be decided by the fact of priority upon the maxim of equity, qui prior est in tempore, potior est in jure. The miner who selects a piece of ground to work must take it as he finds it, subject to prior rights, which have an equal equity, on account of an

equal recognition from the sovereign power. If it is upon a stream the waters of which have not been taken from their bed they can not be taken to his prejudice, but if they have already been diverted, and for as high and legitimate a purpose as the one he seeks to accomplish, he has no right to complain, no right to interfere with the prior occupation of his neighbor, and must abide the disadvantages of his own selection."

The earlier cases which the California courts were called upon to decide involved questions growing out of water rights within the public domain; that is to say, between persons taking water from streams which did not touch lands privately owned.

Because of the uniformity with which the courts in these early cases upheld the doctrine of prior appropriation it came to be very generally believed that the common-law rule of riparian rights had been entirely abolished in California. In fact, however, the question of water rights, as between private riparian owners, had never been definitely determined by the courts. This question was definitely presented to the court for determination in Lux *v.* Haggin, 69 Cal., p. 255.

Lux *v.* Haggin.

In this case the court expressly declared that the common law of riparian rights existed in California as between private land owners. The doctrine was thus established in California that the principle of appropriation and of riparian rights existed side by side, the former applying to the public domain and the latter to lands privately owned. However, when lands were transferred from public to private ownership, riparian rights thus acquired were subject to all prior appropriation but protected from any subsequent appropriation adversely affecting such rights.

The court said:

"The owners of land by or through which a watercourse naturally and usually flows have a right of property in the waters of the stream" (p. 264).

"Neither a grantee of the United States nor the grantee of a private person who was a riparian owner when the code was adopted need rely for the protection of his riparian rights on section 1422 of the civil code. Such persons are protected by constitutional principles" (p. 368).

"The statute of April 13, 1850, adopts as the rule of decision in all the courts of this State the common law of England, not the civil law, nor the 'ancient common law' of the civilians, nor the Mexican law" (p. 379).

"The doctrine of 'appropriation' so called is not the doctrine of the common law" (p. 387).

The Colorado Doctrine of Appropriation.

The doctrine of appropriation may, however, rest upon a wholly different consideration as exemplified by the so-called Colorado doctrine. Proceeding upon the theory that the water in running streams belongs to no one, it is an easy step to assert that it is the property of the State and that the State in its sovereign capacity may determine

the rules governing its use. This conception has prevailed in the State of Colorado and in those States which have adopted the Colorado doctrine.

Of necessity in these States the common-law principle of riparian rights has been entirely abolished, or, in most instances, declared never to have existed, either by provision of their constitution or by declaration of statute. The denial of the existence of the common-law rights of riparian owners is made applicable by the courts of these States to the Federal Government as a riparian owner, with equal effect as in the case of private owners.

States which Have Abolished in Toto the Common-Law Rule of Riparian Rights.

The following States have abolished in toto the common-law rule of riparian rights and adopted the doctrine of appropriation: Arizona, Colorado, Idaho, Nebraska (partially), Nevada, New Mexico, Oregon (partially), Texas (partially), Utah, and Wyoming. In these States it is maintained that the right of appropriation is derived solely from the authority of the State.

States Adopting Both the Common-Law Rule and Appropriation.

The following States have adopted the common-law doctrine of riparian rights as to waters flowing over lands privately owned and the doctrine of prior appropriation as applying to waters upon public lands: California, Kansas, Montana, Nebraska (partially), North Dakota, Oklahoma (doubtful), Oregon (partially), South Dakota, Texas (partially), and Washington. These States base their doctrine of appropriation upon the enactments of the Federal Government, particularly the act of 1866, which in effect validated all rights to the use of water acquired by appropriation, and the desert land act of 1877, which more fully confirmed the jurisdiction of the States over the waters within their borders.

All Water Rights Must be Exercised Subject to Paramount Right of Navigation.

Both the principle of riparian rights and that of prior appropriation are applicable to navigable as well as nonnavigable streams. However, in the case of navigable streams it must be exercised subject to the paramount right of navigation.

The court says, in United States *v.* Rio Grande Dam Irrigation Co., 174 U. S., p. 709:

"It does not follow that the court would be justified in sustaining any proceeding by the Attorney General to restrain any appropriation of the upper waters of a navigable stream. The question is always one of fact, whether such appropriation substantially interferes with the navigable capacity within the limits where navigation is the recognized fact."

Conclusion.

It would thus appear that the law of waters now existing in the several States of the Union has been developed by the applicability

or inapplicability of the common law to the conditions therein existing. The common law, having been found suitable to the conditions and needs of the Eastern and Middle States, has been almost universally adopted. The comparatively small body of statutory law found in these States is simply a definite embodiment of the customs of the people and the practice of the courts. On the other hand, the common-law principle having been found unsuited to the physical conditions and natural development of the Rocky Mountain States, it was soon either partially or wholly set aside by constitutional or statutory enactment and the doctrine of prior appropriation substituted.

It is to be noted, however, that the use of running water, whether acquired by the common law of riparian rights or by prior appropriation, must be exercised for a beneficial use and in a reasonable manner, and, in the case of navigable rivers, subject to the paramount right of navigation.

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APPENDIX VII.

CONSTITUTIONAL PROVISIONS OF VARIOUS STATES RELATING TO WATER COURSES AND THE USE OF WATER.

Compiled by G. W. MOONEY.

Express provisions relating to water courses or the use of water are found in but 18 of the States of the Union. These States are Alabama, Arizona, California, Colorado, Idaho, Louisiana, Michigan, Mississippi, Missouri, Montana, New Mexico, North Dakota, Oklahoma, South Carolina, Tennessee, Utah, Washington, and Wyoming. It will be noted that all these States except five are located west of the Mississippi River, and of the five east of the Mississippi two, Tennessee and Mississippi, border the river.

Under the conditions existing during the early history of the country in those areas from which the Eastern and Middle States were formed the common law of riparian ownership was found adequate and satisfactory. Consequently, with the exception of Michigan and the Southern States above named, there is no mention of the law of waters in their fundamental law and very limited statutory enactment.

The constitutional provisions of Mississippi and Tennessee, together with those of Louisiana and Missouri, relate only to maintaining the navigability of the Mississippi, and to rights of the public and of the citizens of those States in connection therewith. The constitutions of Michigan and South Carolina contain general declarations intended to preserve the free and unobstructed navigation of the streams of those States.

Altogether the most important provisions relating to water courses and the right to the beneficial use of such waters are found in the constitutions of several of the Western States. In these States the common law of riparian rights was found to be inapplicable to existing conditions, either for the development of the natural resources of the State or for the equitable determination of rights between citizens.

The water of natural streams is declared to be the property of the public by the constitutions of Colorado and New Mexico, and to be the property of the State by those of North Dakota and Wyoming. The constitution of Arizona, recently approved, proclaims that the common law of riparian rights shall not obtain or be of force and effect in that State.

The doctrine of prior appropriation is recognized by the constitutions of Arizona, California, Colorado, Idaho, Montana, New Mexico,

Utah (by implication), and Wyoming. In those of Colorado and Idaho perference is given to domestic uses over those for irrigation, and for irrigation over uses for manufacture. By the constitutions of California and Idaho all water appropriated for any beneficial use is declared to be a public use and subject to the control of the State, while in the case of the latter State and also of Colorado the duty is laid on the legislature of regulating charges.

By the constitutions of Colorado, Idaho, Montana, Oklahoma, Washington, and Wyoming the right of eminent domain is granted for the construction of reservoirs, conduits, ditches, and kindred structures over private property, even where the purpose is for a private use.

CONSTITUTION OF ALABAMA.

ARTICLE I.

SEC. 26. That all navigable waters shall remain forever public highways, free to the citizens of the State, and of the United States, without tax, impost, or toll imposed; and that no tax, toll, impost, or wharfage shall be demanded or received from the owner of any merchandise or commodity for the use of the shores, or any wharf erected on the shores or in or over the waters of any navigable stream, unless the same be expressly authorized by the general assembly.

CONSTITUTION OF ARIZONA.

ARTICLE X.

SEC. 5. No lands shall be sold for less than $3 per acre, and no lands which are or shall be susceptible of irrigation under any projects now or hereafter completed or adopted by the United States under legislation for the reclamation of lands, or under any other project for the reclamation of lands, shall be sold at less than $25 per acre: *Provided*, That the State, at the request of the Secretary of the Interior, shall from time to time relinquish such of its lands to the United States as at any time are needed for irrigation works in connection with any such Government project, and other lands in lieu thereof shall be selected from lands of the character named and in the manner prescribed in section 24 of the said enabling act.

SEC. 6. No lands reserved and excepted of the lands granted to this State by the United States, actually or prospectively valuable for the development of water powers or power for hydroelectric use or transmission, which shall be ascertained and designated by the Secretary of the Interior within five years after the proclamation of the President declaring the admission of the State, shall be subject to any disposition whatsoever by the State or by any officer of the State, and any conveyance or transfer of such lands made within said five years shall be null and void.

ARTICLE XVII.

SEC. 1. The common-law doctrine of riparian water rights shall not obtain or be of any force or effect in the State.

SEC. 2. All existing rights to the use of any of the waters in the State for all useful or beneficial purposes are hereby recognized and confirmed.

ARTICLE XX.

Tenth. There are hereby reserved to the United States, with full acquiescence of this State, all rights and powers for the carrying out of the provisions by the United States of the act of Congress entitled "An act appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands," approved June 17, 1902, and acts amendatory thereof or supplementary thereto, to the same extent as if this State had remained a Territory.

CONSTITUTION OF CALIFORNIA.

ARTICLE XIV.

SEC. 1. The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the State, in the manner to be prescribed by law: *Provided*, That the rates of compensation to be collected by any person, company, or corporation in this State for the use of water supplied to any city and county, or city, or town, or the inhabitants thereof, shall be fixed annually by the board of supervisors, or city and county, or city or town council, or other governing body of such city and county, or city, or town, by ordinance or otherwise, in the manner that other ordinances or legislative acts or resolutions are passed by such body, and shall continue in force for one year and no longer. Such ordinances or resolutions shall be passed in the month of February of each year and take effect on the 1st day of July thereafter. Any board or body failing to pass the necessary ordinances or resolutions fixing water rates, where necessary, within such time, shall be subject to peremptory process to compel action at the suit of any party interested, and shall be liable to such further processes and penalties as the legislature may prescribe. Any person, company, or corporation collecting water rates in any city and county, or city, or town in this State, otherwise than as so established, shall forfeit the franchises and water works of such person, company, or corporation to the city and county, or city, or town where the same are collected, for the public use.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city and county, or town, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

CONSTITUTION OF COLORADO.

ARTICLE II.

SEC. 14. That private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity

and except for reservoirs, drains, flumes, or ditches on or across the lands of others, for agricultural, mining, milling, domestic, or sanitary purposes.

ARTICLE XVI.

SEC. 5. The water of every natural stream, not heretofore appropriated, within the State of Colorado, is hereby declared to be the property of the public, and the same is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided.

SEC. 6. The right to divert unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes.

SEC. 7. All persons and corporations shall have the right of way across public, private, and corporate lands for the construction of ditches, canals, and flumes for the purpose of conveying water for domestic purposes, for the irrigation of agricultural lands, and for mining and manufacturing purposes, and for drainage, upon payment of just compensation.

SEC. 8. The general assembly shall provide by law that the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for the use of water, whether furnished by individuals or corporations.

CONSTITUTION OF IDAHO.

ARTICLE I.

SEC. 14. The necessary use of lands for the construction of reservoirs or storage basins, for the purposes of irrigation, or for the rights of way for the construction of canals, ditches, flumes, or pipes to convey water to the place of use, for any useful, beneficial, or necessary purpose, or for drainage; or for the drainage of mines, or the working thereof, by means of roads, railroads, tramways, cuts, tunnels, shafts, hoisting works, dumps, or other necessary means to their complete development, or any other use necessary to the complete development of the material resources of the State or the preservation of the health of its inhabitants, is hereby declared to be a public use and subject to the regulation and control of the State.

Private property may be taken for public use, but not until a just compensation, to be ascertained in a manner prescribed by law, shall be paid therefor.

ARTICLE XV.

SEC. 1. The use of all waters now appropriated, or that may hereafter be appropriated for sale, rental, or distribution; also of all water originally appropriated for private use, but which after such

appropriation has heretofore been, or may hereafter be, sold, rented, or distributed, is hereby declared to be a public use and subject to the regulation and control of the State, in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses, shall never be denied. Priority of appropriation shall give the better right as between those using the water; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purposes; and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes. And in any organized mining district, those using the water for mining purposes or milling purposes connected with mining shall have preference over those using the same for manufacturing or agricultural purposes. But the usage by such subsequent appropriators shall be subject to such provisions of law regulating the taking of private property for public or private use, as referred to in section 14 of Article I of this constitution.

SEC. 4. Whenever any waters have been, or shall be appropriated or used for agricultural purposes, under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have once been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with the view of receiving the benefits of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns, shall not thereafter, without his consent, be deprived of the annual use of the same, when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor, and compliance with such equitable terms and conditions as to the quantity used and times of use, as may be prescribed by law.

SEC. 5. Whenever more than one person has settled upon, or improved land with a view of receiving water for agricultural purposes, under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislature, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 6. The legislature shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

CONSTITUTION OF LOUISIANA.

ART. 290. Riparian owners of property on navigable rivers, lakes, and streams, within any city or town in this State having a population in excess of 5,000 shall have the right to erect and maintain on the batture or banks owned by them such wharves, buildings, and improvements as may be required for the purpose of commerce and navigation, subject to the following conditions, and not otherwise, to wit: Such owners shall first obtain the consent of the council, or other governing authority, and of the board of levee commissioners, within whose municipal or levee district jurisdiction such wharves, buildings, and improvements are to be erected, and such consent having been obtained, shall erect the same in conformity to plans and specifications which shall have been first submitted to, and approved by, the engineer of such council, or other governing authority; and when so erected, such wharves, buildings, and improvements shall be and remain, subject to the administration and control of such council, or other governing authority, with respect to their maintenance and to the fees and charges to be exacted for their use by the public, whenever any fee or charge is authorized to be, and is, made; and shall be and remain subject to the control of such board of levee commissioners, in so far as may be necessary for the maintenance and administration of the levees in its jurisdiction. The council, or other governing authority, shall have the right to expropriate such wharves, buildings, and improvements, whenever necessary for public purposes, upon reimbursing the owner the cost of construction, less such depreciation as may have resulted from time and decay; such reimbursement, hovewer, in no case to exceed the actual market value of the property: *Provided*, That nothing in this article shall be construed as affecting the right of the State, or of any political subdivision thereof, or of the several boards of levee commissioners to appropriate without compensation such wharves, buildings, and improvements, when necessary for levee purposes. * * *

CONSTITUTION OF MICHIGAN.

ARTICLE XVIII.

SEC. 4. No navigable stream in this State shall be either bridged or dammed without authority from the board of supervisors of the proper county under the provisions of law. No such law shall prejudice the right of individuals to the free navigation of such streams, or preclude the State from the further improvement of the navigation of such streams.

CONSTITUTION OF MISSISSIPPI.

SEC. 81. The legislature shall never authorize the permanent obstruction of any of the navigable waters of the State, but may provide for the removal of such obstructions as now exist, whenever the public welfare demands. This section shall not prevent the construction, under proper authority, of drawbridges for railroads or other roads, nor the construction of booms "and chutes" for logs in such manner as not to prevent the safe passage of vessels or logs under regulations to be provided by law.

SEC. 90. The legislature shall not pass local, private, or special laws in any of the following enumerated cases, but such matters shall be provided for only by general laws, viz:

(g) Granting to any person, corporation, or association the right to have any ferry, bridge, road, or fish trap.

(q) Relating to stock laws, watercourses, and fences.

CONSTITUTION OF MISSOURI.

ARTICLE I.

SEC. 1. The boundaries of the State, as heretofore established by law, are hereby ratified and confirmed. The State shall have concurrent jurisdiction on the Mississippi River and every other river bordering on the State, so far as the said rivers shall form a common boundary to this State and any other State or States; and the River Mississippi and the navigable rivers and waters leading to the same shall be common highways, and forever free to the citizens of this State and of the United States, without any tax, duty, impost, or toll therefor, imposed by this State.

CONSTITUTION OF MONTANA.

ARTICLE III.

SEC. 15. The use of all water now appropriated, or that may hereafter be appropriated for sale, rental, distribution, or other beneficial use and the right of way over the lands of others, for all ditches, drains, flumes, canals, and aqueducts, necessarily used in connection therewith, as well as the sites for reservoirs necessary for collecting and storing the same, shall be held to be a public use. Private roads may be opened in the manner to be prescribed by law, but in every case the necessity of the road, and the amount of all damage to be sustained by the opening thereof, shall be first determined by a jury, and such amount, together with the expenses of the proceeding, shall be paid by the person to be benefited.

CONSTITUTION OF NEW MEXICO.

ARTICLE XVI.

SEC. 1. All existing rights to the use of any waters in this State for any useful or beneficial purpose are hereby recognized and confirmed.

SEC. 2. The unappropriated water of every natural stream, perennial or torrential, within the State of New Mexico is hereby declared to belong to the public and to be subject to appropriation for beneficial use, in accordance with the laws of the State. Priority of appropriation shall give the better right.

SEC. 3. Beneficial use shall be the basis, the measure, and the limit of the right to the use of water.

SEC. 4. The legislature is authorized to provide by law for the organization and operation of drainage districts and systems.

Constitution of North Dakota.

ARTICLE XVII.

Sec. 210. All flowing streams and natural watercourses shall forever remain the property of the State for mining, irrigating, and manufacturing purposes.

Constitution of Oklahoma.

ARTICLE II.

Sec. 23. No private property shall be taken or damaged for private use, with or without compensation, unless by consent of the owner, except for private ways of necessity, or for drains and ditches across lands of others for agricultural, mining, or sanitary purposes, in such manner as may be prescribed by law.

Constitution of South Carolina.

ARTICLE I.

Sec. 28. All navigable waters shall forever remain public highways, free to the citizens of the State and the United States without tax, impost, or toll imposed, and no tax, toll, impost, or wharfage shall be imposed, demanded, or received from the owners of any merchandise or commodity for the use of the shores or any wharf erected on the shores or in or over the waters of any navigable stream unless the same be authorized by the general assembly.

ARTICLE XIV.

Sec. 1. The State shall have concurrent jurisdiction on all rivers bordering on this State, so far as such rivers shall form a common boundary to this and any other State bounded by the same, and they, together with all navigable waters within the limits of the State, shall be common highways and forever free, as well to the inhabitants of this State as to the citizens of the United States, without any tax or impost therefor, unless the same be expressly provided for by the general assembly.

Constitution of Tennessee.

ARTICLE I.

Sec. 29. That an equal participation in the free navigation of the Mississippi is one of the inherent rights of the citizens of this State; it can not, therefore, be conceded to any prince, potentate, power, person, or persons whatever.

Constitution of Utah.

ARTICLE XI.

Sec. 6. No municipal corporation shall, directly or indirectly, lease, sell, alien, or dispose of any waterworks, water rights, or

sources of water supply now or hereafter to be owned or controlled by it; but all such waterworks, water rights and sources of water supply now owned or hereafter to be acquired by any municipal corporation shall be preserved, maintained, and operated by it for supplying its inhabitants with water at reasonable charges: *Provided*, That nothing herein contained shall be construed to prevent any such municipal corporation from exchanging water rights or sources of water supply for other water rights or sources of water supply of equal value and to be devoted in like manner to the public supply of its inhabitants.

ARTICLE XIII.

SEC. 3. The legislature shall provide by law a uniform and equal rate of assessment and taxation on all property in the State, according to its value in money, and shall prescribe by general law such regulations as shall secure a just valuation for taxation of all property, so that every person and corporation shall pay a tax in proportion to the value of his, her, or its property: *Provided*, That * * * ditches, canals, reservoirs, pipes, and flumes owned and used by individuals or corporations for irrigating lands owned by such individuals or corporations, or the individual members thereof, shall not be separately taxed as long as they shall be owned and used exclusively for such purpose.

ARTICLE XVII.

SEC. 1. All existing rights to the use of any of the waters in this State for any useful or beneficial purpose are hereby recognized and confirmed.

CONSTITUTION OF WASHINGTON.

ARTICLE I.

SEC. 16. Private property shall not be taken for private use, except for private ways of necessity, for drains, flumes, or ditches on or across the lands of others for agricultural, domestic, or sanitary purposes. * * *

ARTICLE XV.

SEC. 1. The legislature shall provide for the appointment of a commission whose duty it shall be to locate and establish harbor lines in the navigable waters of all harbors, estuaries, bays, and inlets of this State, wherever such navigable waters lie within or in front of the corporate limits of any city, or within 1 mile thereof upon either side. The State shall never give, sell, or lease to any private person, corporation, or association any rights whatever in the waters beyond such harbor lines, nor shall any of the area lying between any harbor line and the line of ordinary high tide, and within not less than 50 feet nor more than 600 feet of such harbor line (as the commission shall determine), be sold or granted by the State, nor its rights to control the same relinquished, but such area shall be forever reserved for landings, wharves, streets, and other conveniences of navigation and commerce.

SEC. 2. The legislature shall provide general laws for the lease of the right to build and maintain wharves, docks, and other structures upon the areas mentioned in section 1 of this article, but no lease shall be made for any term longer than 30 years, or the legislature may provide by general laws for the building and maintaining upon such area wharves, docks, and other structures.

SEC. 3. Municipal corporations shall have the right to extend their streets over intervening tide lands to and across the area reserved as herein provided.

ARTICLE XXI.

SEC. 1. The use of the waters of this State for irrigation, mining, and manufacturing purposes shall be deemed a public use.

CONSTITUTION OF WYOMING.

ARTICLE I.

SEC. 31. Water being essential to industrial prosperity, of limited amount and easy of diversion from its natural channels, its control must be in the State, which, in providing for its use, shall equally guard all the various interests involved.

SEC. 32. Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and for reservoirs, drains, flumes, or ditches on or across the lands of others for agricultural, mining, milling, domestic, or sanitary purposes, nor in any case without due compensation.

ARTICLE VIII.

SEC. 1. The water of all natural streams, springs, lakes, or other collections of still water within the boundaries of the State are hereby declared to be the property of the State.

SEC. 2. There shall be constituted a board of control, to be composed of the State engineer and superintendents of the water divisions, which shall, under such regulations as may be prescribed by law, have the supervision of the waters of the State and of their appropriation, distribution, and diversion and of the various officers connected therewith. Its decisions to be subject to review by the courts of the State.

SEC. 3. Priority of appropriation for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

SEC. 4. The legislature shall by law divide the State into four (4) water divisions and provide for the appointment of superintendents thereof.

SEC. 5. There shall be a State engineer, who shall be appointed by the governor of the State and confirmed by the senate. He shall hold his office for the term of six years, or until his successor shall have been appointed and shall have qualified. He shall be president of the board of control, and shall have general supervision of the waters of the State and of the officers connected with its

distribution. No person shall be appointed to this position who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

ARTICLE XIII.

SEC. 5. Municipal corporations shall have the same right as individuals to acquire rights by prior appropriation and otherwise to the use of water for domestic and municipal purposes, and the legislature shall provide by law for the exercise upon the part of incorporated cities, towns, and villages of the right of eminent domain for the purpose of acquiring from prior appropriators, upon the payment of just compensation, such water as may be necessary for the wellbeing thereof and for domestic uses.

36135°—S. Doc. 469, 62-2——21

Appendix VIII.

FEDERAL STATUTES RELATING TO WATER POWER.

G. W. Mooney.

The following compilation of statutes was originally prepared by Alexander Mackenzie, brigadier general, United States Army, Chief of Engineers, but has now been revised and brought down to date.

Abstract of legislation enacted by Congress in relation to the construction of power dams in the navigable waters of the United States between 1789 and Jan. 1, 1912.[1]

	Location.	Grantee.	Date.	Reference.
1	General dam act		June 21, 1906	Vol. 34, p. 386. (Public, No. 262.)
2	General dam act		June 23, 1910	Vol. 36, p. 593. (Public, No. 246.)
2	Bear River, Miss	North Mississippi Traction Co.	Apr. 23, 1906	Vol. 34, p. 130. (Public, No. 119.)
4	Bear River, Miss	Andrews & Jourdan	Feb. 25, 1907	Vol. 34, p. 929. (Public, No. 115.)
5	Black Warrior River, Ala. (Mulberry Fork).	T. H. Friel	Mar. 16, 1908 Aug. 22, 1911	Vol. 35, p. 45. (Public, No. 59.) Vol. 37, p. —. (Public, No. 40.)
6	Cahaba River, Ala. (Centerville).	Cahaba Power Co	Mar. 6, 1908	Vol. 35, p. 37. (Public, No. 38.)
7	Choctawhatchee River (Newton, Ala.).	Choctawhatchee Power Co.	Apr. 5, 1906	Vol. 34, p. 103. (Public, No. 84.)
8	Choctawhatchee River, Ala. (below Newton-Ozark Road).	Andrew J. Smith et al	Mar 10, 1908 Feb. 13, 1911	Vol. 35, p. 40. (Public, No. 47.) Vol. 36, p. 905. (Public, No. 361.)
9	Colorado River near mouth of Pyramid Canyon.	Chucawalla Development Co.	Feb. 15, 1911	Vol. 36, p. 909. (Public, No. 374.)
10	Colorado River in Yuma County, Ariz.[2]	Greeley-Arizona Irrigation Co.	Mar. 3, 1911	Vol. 36, p. 1081. (Public, No. 464.)
11	Coosa River, Ala. (Lock No. 2).	Riparian owners	May 9, 1906	Vol. 34, p. 183. (Public, No. 150.)
12	Coosa River, Ala. (Dam No. 4). Completion of Government dam and use of water power by private parties.	Riparian owners, etc	June 4, 1906	Vol. 34, p. 211. (Public, No. 196.)
13	Coosa River, Ala. (Dam No. 12).	Alabama Power Co	Mar. 4, 1907	Vol. 34, p. 1288. (Public, No. 247.)
14	Coosa River, Ala	Ragland Water Power Co.	Feb. 27, 1911	Vol. 36, p. 939. (Public, No. 425.)
15	Crow Wing River, Minn	Judd Wright	June 16, 1906	Vol. 34, p. 296. (Public, No. 238.)
16	Cumberland River and its South Fork above Burnside, Ky.	Cumberland River Improvement Co.	Mar. 3, 1905	Vol. 33, pp. 1132, 1133. (Public, No. 215, pp. 18 (pars. 1 to 6) and 19 (par. 1).)

[1] This list does not include cases in which dams appear to have been intended for purposes otherwise than for the generation of mechanical power.
[2] This dam is intended primarily for diversion.

Abstract of legislation enacted by Congress in relation to the construction of power dams, etc.—Continued.

	Location.	Grantee.	Date.	Reference.
17	Cumberland River (Dam No. 1, above Nashville, Tenn.). Leasing of water power created by the Government dam.	....	June 13, 1902 June 28, 1902	Vol. 32, p. 358. (Public, No. 154, p. 31, par. 3.) Vol. 32, p. 408. (Public, No. 180.)
18	Flint River, Ga. (Porter Shoals).	Albany Power & Manufacturing Co.	Feb. 5, 1907	Vol. 34, p. 878. (Public, No. 62.)
19	Goose Creek, S. C.	Charleston Light & Water Co.	June 14, 1906	Vol. 34, p. 265. (Public, No. 230.)
20	James River, Mo. (Stone County).	J. W. Vance et al	Feb. 24, 1911	Vol. 36, p. 929. (Public, No. 412.)
21	Kansas (Kaw) River, Kans..	Topeka Water & Electric Power Co.	June 6, 1892	Vol. 27, p. 46. (Public, No. 77.)
22	Kansas (Kaw) River, Kans.	Chicago-Topeka Light, Heat & Power Co.	Jan. 22, 1894	Vol. 28, p. 27. (Public, No. 14.)
23	Klamath Indian Reservation, Oreg. Indian appropriation act, under Department of the Interior.	Private parties	June 21, 1906	Vol. 34, pp. 325 and 368. (Public, No. 258.)
24	Little River, Ala. (Blanche). power plant.	Henry T. Henderson et al..	June 30, 1906	Vol. 34, p. 818. (Public, No. 408.)
25	Minnesota River	Minnesota River Improvement & Power Co.	Feb. 24, 1911	Vol. 36, p. 932. (Public, No. 421.)
26	Mississippi River (Bemidji, Minn.).	Kirby Thomas et al	Mar. 3, 1905 Feb. 1, 1908	Vol. 33, p. 1043. (Public, No. 207.) Vol. 35, p. 3. (Public, No. 8.)
27	Mississippi River (Bemidji, Minn.).	Morrison & Haines	June 4, 1906	Vol. 34, p. 210. (Public, No. 194.)
28	Mississippi River (Brainerd, Minn.).	Mississippi Water Power & Boom Co.	Apr. 15, 1886	Vol. 24, p. 12.
29	Mississippi River (Clearwater, Minn.).	The Mississippi River Power Co.	June 14, 1906 Mar. 2, 1907	Vol. 34, p. 266. (Public, No. 231.) Vol. 34, p. 1235. (Public, No. 205.)
30	Mississippi River (Des Moines Rapids).	Des Moines Rapids Power Co.	Feb. 24, 1894	Vol. 28, p. 38. (Public, No. 28.)
31	Mississippi River (Des Moines Rapids at Keokuk, Iowa).	Keokuk & Hamilton Water Power Co.	Feb. 8, 1901 Feb. 26, 1904 Feb. 9, 1905	Vol. 31, p. 764. (Public, No. 43.) Vol. 33, p. 56. (Public, No. 32.) Vol. 33, p. 712. (Public, No. 65.)
32	Mississippi River (Grand Rapids, Minn.).	Grand Rapids Water Power & Boom Co.	Feb. 27, 1899 Feb. 27, 1900	Vol. 30, p. 904. (Public, No. 80.) Vol. 31, p. 33. (Public, No. 26.)
33	Mississippi River (Little Falls, Minn.).	Little Falls Water Power Co.	July 3, 1886	Vol. 24, p. 123.
34	Mississippi River (Minneapolis, Minn., to Coon Rapids).	Twin City Rapid Transit Co.	Mar. 5, 1898 Apr. 12, 1900	Vol. 30, p. 253. (Public, No. 28.) Vol. 31, p. 75. (Public, No. 67.)
35	Mississippi River (Minneapolis to St. Paul). Commission to report concerncerning use of surplus water flowing over Government dams.	....	June 25, 1906	Vol. 34, p. 456. (Public, No. 282.)
36	Mississippi River (Monticello, Minn.).	The Mississippi River Power Co.	June 14, 1906 Mar. 2, 1907	Vol. 34, p. 264. (Public, No. 229.) Vol. 34, p. 1235. (Public, No. 204.)
37	Mississippi River (in Morrison County).	The Pike Rapids Power Co.	June 4, 1906 Mar. 2, 1907 Mar. 4, 1911	Vol. 34, p. 209. (Public, No. 193.) Vol. 34, p. 1219. (Public, No. 179.) Vol. 36, p. 1359. (Public, No. 517.)
38	Mississippi River (Otsego, Minn., between Wright and Sherburne Counties).	Minnesota Power & Trolley Co.	Mar. 12, 1904 Mar. 22, 1906	Vol. 33, p. 66. (Public, No. 47.) Vol. 34, p. 84. (Public, No. 63.)
39	Mississippi River (Rock Island, Ill.).[1]			

[1] Dam authorized in 1837 by charter of State of Illinois to private parties; charter extended by State in 1839. Developed by Moline Water Power Co. et al. Further developed by Ordnance Department, U. S. Army, under authority of acts of Congress of Apr. 19, 1864 (vol. 13, p. 50), and June 27, 1866 (vol. 14, pp. 75 and 76). See also in this connection joint resolutions of Congress of Mar. 2, 1867 (vol. 14, p. 573), and Mar. 3, 1877 (vol. 19, p. 410), act of Congress of Mar. 3, 1879 (vol. 20, p. 387, first paragraph), and joint resolution of Congress of June 20, 1879 (vol. 21, p. 51). For history of operations by Ordnance Department concerning the development of this water power see "A history of the Rock Island Arsenal," etc., 1877, published by the Ordnance Department, U. S. Army.

Abstract of legislation enacted by Congress in relation to the construction of power dams, etc.—Continued.

	Location.	Grantee.	Date.	Reference.
40	Mississippi River (Rock Island Rapids, between Davenport and Le Claire, Iowa).	Davenport Water Power Co.	Apr. 5, 1904	Vol. 33, p. 158. (Public, No. 82.)
			Feb. 5, 1907	Vol. 34, p. 876. (Public, No. 56.)
41	Mississippi River (Sauk Rapids, St. Cloud, Minn.).	St. Cloud Water Power & Mill Co.	July 5, 1884	Vol. 23, p. 154.
42	Mississippi River (village of Sauk Rapids, Minn.).	Sauk Rapids Water Power Co.	Feb. 26, 1904	Vol. 33, p. 52. (Public, No. 28.)
			Mar. 2, 1907	Vol. 34, p. 1058. (Public, No. 164.)
			Feb. 13, 1911	Vol. 36, p. 902. (Public, No. 352.)
			Feb. 24, 1911	Vol. 36, p. 931. (Public, No. 420.)
43	Mississippi River (Sauk Rapids, between village of Sauk Rapids and St. Cloud, Minn.).	Sauk Rapids Manufacturing Co.	Feb. 20, 1905	Vol. 33, p. 723. (Public, No. 83.)
44	Mississippi River (between Stearns and Sherburne Counties, Minn., at Augusta).	The St. Cloud Electric Power Co.	June 28, 1906	Vol. 34, p. 537. (Public, No. 315.)
45	Mississippi River (Watab, Minn.).	Watab Rapids Power Co...	Apr. 23, 1904	Vol. 33, p. 295. (Public, No. 151.)
46	Mississippi River (Hennepin County, Minn.).	Great Northern Development Co.	Jan. 12, 1911	Vol. 36, p. 893. (Public, No. 333.)
47	Missouri River (Fort Benton, Mont., somewhere within a distance of 30 miles above).	Missouri River Improvement Co.	Feb. 20, 1907	Vol. 34, p. 912. (Public, No. 98.)
48	Missouri River (Ox Bow Bend, Mont.).	Ox Bow Power Co.........	Apr. 28, 1904	Vol. 33, p. 570. (Public, No. 253.)
			Mar. 4, 1907	Vol. 34, p. 1415. (Public, No. 271.)
49	Missouri River (Stubbs Ferry to headwaters). General authority for construction of dams.	....	June 3, 1896	Vol. 29, p. 231. (Public, No. 175, p. 34, par. 1.)
50	Missouri River (near Stubbs Ferry, Mont.).	Missouri River Power Co...	June 8, 1894	Vol. 28, p. 91. (Public No. 85.)
51	Missouri River (vicinity of Buck Rapids, Mont.).	Capital City Improvement Co.	Apr. 12, 1906	Vol. 34, p. 111. (Public, No. 93.)
52	Namakan Lake, Kettle Falls, Minn.	Rainey River Improvement Co.	Feb. 24, 1911	Vol. 36, p. 931. (Public, No. 418.)
53	New River, Va. and W. Va. (at Stevens Creek, Va.).	Fries & Ruffin.............	June 4, 1900	Vol. 31, p. 264. (Public, No. 142.)
54	New River, Foster Falls, Va.	Virginia Iron, Coal & Coke Co.	Feb. 18, 1911	Vol. 36, p. 921. (Public, No. 395.)
55	New River, Wythe County, Va.	Ivanhoe Furnace Corporation.	Feb. 18, 1911	Vol. 36, p. 922. (Public, No. 398.)
56	Niobrara River, Nebr. (Fort Niobrara Military Reservation.).	C. H. Cornell...............	June 18, 1906	Vol. 34, p. 297. (Public, No. 239.)
			Feb. 18, 1911	Vol. 36, p. 920. (Public, No. 393.)
57	Osage River, Mo. (Warsaw).	City of Warsaw............	Jan. 14, 1901	Vol. 31, p. 729. (Public, No. 7.)
58	Pea River, Ala. (Elba)......	Pea River Power Co.......	Feb. 23, 1906	Vol. 34, p. 18. (Public, No. 20.)
59	Pend Oreille River, Wash. (Big or Metaline Falls).	Pend d'Oreille Development Co.	June 1, 1906	Vol. 34, p. 205. (Public, No. 187.)
60	Pend Oreille River, Wash. (near Pierwee Creek).	.....do.....................	Feb. 25, 1907	Vol. 34, p. 931. (Public, No. 119.)
61	Rainy River, Minn.........	Koochiching Co. and Rainy River Improvement Co.	May 4, 1898	Vol. 30, p. 398. (Public, No. 80.)
			May 4, 1900	Vol. 31, p. 167. (Public, No. 89.)
			June 28, 1902	Vol. 32, p. 485. (Public, No. 186.)
			Feb. 25, 1905	Vol. 33, p. 814. (Public, No. 103.)
			May 23, 1908	Vol. 35, p. 273. (Public, No. 138.)
62	Red Lake River, Minn......	W. J. Murphy............	Mar. 16, 1906	Vol. 34, p. 65. (Public, No. 49.)
63	Rock River, Ill. (Grand Detour.)	S. B. Newberry et al.......	Feb. 16, 1906	Vol. 34, p. 14. (Public, No. 16.)
64	Rock River, Ill. (Lyndon)...	Edward A. Smith et al.....	Mar. 3, 1905	Vol. 33, p. 1004. (Public, No. 171.)
			Feb. 25, 1907	Vol. 34, p. 933. (Public, No. 124.)
			Feb. 18, 1911	Vol. 36, p. 920. (Public, No. 392.)

Abstract of legislation enacted by Congress in relation to the construction of power dams, etc.—Continued.

	Location.	Grantee.	Date.	Reference.
65	Rock River, Ill. (at Vandruffs and at Carrs Islands).	S. S. Davis	May 1, 1906 Mar. 3, 1909	Vol. 34, p. 155. (Public, No. 137.) Vol. 35, p. 819. (Public, No. 317.)
66	Rock River, Ill. (Sterling). (Power, etc.).	Sterling Hydraulic Co.	Mar. 2, 1907	Vol. 34, p. 1103. (Public, No. 168, p. 33, par. 5.)
67	Rock River, Ill. (Byron)	Byron Water Power Co.	Feb. 18, 1911	Vol. 36, p. 922. (Public, No. 397.)
68	St. Croix River, Wis. and Minn. (St. Croix Falls, Wis.).	St. Croix Falls, Wisconsin Improvement Co., and St. Croix Falls, Minnesota Improvement Co.	Feb. 7, 1903	Vol. 32, p. 802. (Public, No. 64.)
69	St. Joseph River, Mich. (Berrien Springs).	Berrien Springs Power & Electric Co.	Apr. 5, 1906	Vol. 34, p. 102. (Public, No. 85.)
70	St. Joseph River, Mich. (Mottville.)	H. L. Hartenstein	Mar. 2, 1907	Vol. 34, p. 1254. (Public, No. 238.)
71	St. Joseph River, Mich. (Sturgis).	City of Sturgis	Jan. 12, 1911	Vol. 36, p. 893. (Public, No. 332.)
72	St. Marys' River, Mich.	Michigan Lake Superior Power Co.	June 13, 1902 Mar. 3, 1909	Vol. 32, p. 361. (Public, No. 154.) Vol. 35, p. 821. (Public, No. 317.)
73	Savannah River, Ga., and S. C. (Andersonville shoals).	J. R. Earle Development Co.	Mar. 2, 1907	Vol. 34, p. 1240. (Public, No. 214.)
74	Savannah River, Ga., and S. C. (Calhoun Falls).	Hugh MacRae Co.	Mar. 2, 1907	Vol. 34, p. 1240. (Public, No. 212.)
75	Savannah River, Ga., and S. C. (Cherokee shoals).	.....do	Mar. 2, 1907	Vol. 34, p. 1255. (Public, No. 239.)
76	Savannah River, Ga., above Augusta (at Dortons Creek, Prices Island, and Crouchs Bluff).	Twin City Power Co.	Feb. 8, 1901 Feb. 27, 1907 Feb. 29, 1908	Vol. 31, p. 763. (Public, No. 41.) Vol. 34, p. 1000. (Public, No. 134.) Vol. 35, p. 36. (Public, No. 36.)
77	Savannah River, Ga., (Gregg Shoals).	Savannah River Power Co.	Feb. 5, 1907	Vol. 34, p. 876. (Public, No. 55.)
78	Savannah (Tugaloo) River, Ga. and S. C. (Hattons Ford).	Hugh MacRae Co.	Mar. 2, 1907	Vol. 34, p. 1240. (Public, No. 213.)
79	Savannah River, Ga. and S. C. (McDaniel Shoals).	Anderson Guaranty & Trust Co.	Mar. 2, 1907	Vol. 34, p. 1238. (Public, No. 208.)
80	Savannah River, Ga., and S. C. (Middleton Shoals).	.....do	Mar. 2, 1907	Vol. 34, p. 1239. (Public, No. 210.)
81	Savannah River, Ga. and S. C. (Trotters Shoals).	Hugh MacRae Co.	Mar. 2, 1907	Vol. 34, p. 1241. (Public, No. 215.)
82	Savannah River, Ga. and S. C. (Turner Shoals).	Anderson Guaranty & Trust Co.	Mar. 2, 1907	Vol. 34, p. 1239. (Public, No. 209.)
83	Savannah River, Ga. (Stevens Creek).	J. L. Hankinson, et al.	Aug. 5, 1909	Vol. 36, p. 180. (Public, No. 9.)
84	Savannah River, Cherokee Shoals.	Hugh MacRae et al.	Feb. 18, 1911	Vol. 36, p. 922. (Public, No. 396.)
85	Spokane River, Wash. Under Department of the Interior.	Private parties	Mar. 3, 1905	Vol. 33, p. 1006. (Public, No. 173.)
86	Tennessee River, Ala. (Elk River Shoals to Florence).	Report by a board of engineers called for.	Mar. 2, 1907	Vol. 34, p. 1094. (Public, No. 168, p. 23, par. 5.)
87	Tennessee River, Ala. (Hales Bar, near Scott Point). The provisions of the last two acts cited are merely appropriations for certain work assumed by the General Government.	City of Chattanooga etc., and Chattanooga & Tennessee River Power Co.	Apr. 26, 1904 Jan. 7, 1905 Mar. 3, 1905 Mar. 2, 1907 Aug. 5, 1909	Vol. 33, p. 309. (Public, No. 169.) Vol. 33, p. 603. (Public, No. 6.) Vol. 33, p. 1133. (Public, No. 215, p. 19, par. 5.) Vol. 34, p. 1093. (Public, No. 168, p. 23, par. 4.) Vol. 36, p. 181. (Public, No. 11.)
88	Tennessee River, Ala. (Muscle Shoals).	General authority for construction of dams.	Mar. 6, 1906	Vol. 34, p. 52. (Public, No. 35.)
89	Tennessee River, Ala. (Muscle Shoals).	Muscle Shoals Power Co.	Mar. 3, 1899 June 6, 1900 Mar. 1, 1901 Feb. 18, 1903	Vol. 30, p. 1351. (Public, No. 201.) Vol. 31, p. 274. (Public, No. 151.) Vol. 31, p. 846. (Public, No. 108.) Vol. 32, p. 839. (Public, No. 96.)

Abstract of legislation enacted by Congress in relation to the construction of power dams, etc.—Continued.

	Location.	Grantee.	Date.	Reference.
	Tugaloo River (Hattons Ford). See Savannah River (67), supra.			
90	Turtle Bay, Anahuac, Tex.[1]	Lone Star Canal Co.	June 25.1910	Vol. 36, p. 828. (Public, No. 278.)
91	Wabash River or tributaries, Ill. (above Grand Rapids Dam). To draw water by canal, flume, or race.	Mount Carmel Development Co.	Feb. 14, 1889 Feb. 12.1901 Mar. 3, 1909	Vol. 25, p. 670. Vol. 31, p. 785. Vol. 36, p. 819. (Public, No. 317.)
92	White River, Ark. (Lock and Dam No. 1). For canals, power stations, etc.	Batesville Power Co.	June 28, 1906	Vol. 34, p. 536. (Public, No. 313.)
93	White River, Ark. (above Lock No. 3).	J. A. Omberg, jr.	June 29.1906	Vol. 34, p. 628. (Public, No. 368.)
94	White River, Taney County, Mo.	Ozark Power & Water Co.	Feb. 4, 1911	Vol. 36, p. 897. (Public, No. 342.)
95	Additional miscellaneous legislation.			

[1] Not primarily for power purposes.

Statutes relating to water power on the public domain.

	Subject.		Date.	Reference.
96	Act of 1866		July 26, 1866	Rev. Stats., sec. 2339.
97	Act of 1870		July 9, 1870	Rev. Stats., sec. 2340.
98	Desert-land act		Mar. 3, 1877	26 Stat., 52.
99	Reservoir sites		Feb. 26.1897	Vol. 29, p. 599. (Public, No. 95.)
100	Forest reserves		Mar. 3, 1891	Vol. 26, p. 1095.
101	Forest reserves under Secretary of the Interior.		June 4, 1897	Vol. 30, p. 34.
102	Revocable permits		Feb. 15, 1901	Vol. 31, p. 790. (Public, No. 64.)
103	Forest reserves transferred to Secretary of Agriculture.		Feb. 1, 1905	Vol. 33, p. 628. (Public, No. 34.)
104	Withdrawal act		June 25, 1910	Vol. 36, p. 847. (Public, No. 303.)
105	Rules of the Forest Service		Dec. 28, 1910	

(1)

CHAP. 3508.—An Act To regulate the construction of dams across navigable waters.

June 21, 1906.
Vol. 34, p. 386.
[H. R. 8428.]
[Public, No. 262.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That when, hereafter, authority is granted by Congress to any persons to construct and maintain a dam for water power or other purposes across any of the navigable waters of the United States, such dams [*sic*] shall not be built or commenced until the plans and specifications for its construction, together with such drawings of the proposed construction and such map of the proposed location as may be required for a full understanding of the subject, have been submitted to the Secretary of War and Chief of Engineers for their approval, or until they shall have approved such plans and specifications and the location of such dam and accessory works; and when the plans for any dam to be constructed under the provisions

Dams.
Regulations for constructing, over navigable waters.

Approval of Secretary of War and Chief of Engineers.
Changes.

of this Act have been approved by the Chief of Engineers and by the Secretary of War it shall not be lawful to deviate from such plans either before or after completion of the structure unless the modification of such plans has previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *Provided*, That in approving said plans and location such conditions and stipulations may be imposed as the Chief of Engineers and the Secretary of War may deem necessary to protect the present and future interests of the United States, which may include the condition that such persons shall construct, maintain, and operate, without expense to the United States, in connection with said dam and appurtenant works, a lock or locks, booms, sluices, or any other structures which the Secretary of War and the Chief of Engineers at any time may deem necessary in the interest of navigation, in accordance with such plans as they may approve, and also that whenever Congress shall authorize the construction of a lock, or other structures for navigation purposes, in connection with such dam, the person owning such dam shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States a free use of water power for building and operating such constructions.

Proviso. Conditions. Approaches, etc., to locks. Water power.

Rights reserved for navigation.

SEC. 2. That the right is hereby reserved to the United States to construct, maintain, and operate, in connection with any dam built under the provisions of this Act, a suitable lock or locks, or any other structures for navigation purposes, and at all times to control the said dam and the level of the pool caused by said dam to such an extent as may be necessary to provide proper facilities for navigation.

Flowage, etc., damages. Lights, fishways, etc.

SEC. 3. That the person, company, or corporation building, maintaining, or operating any dam and appurtenant works, under the provisions of this Act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise. The persons owning or operating any such dam shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe.

Forfeiture of rights.

SEC. 4. That all rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such rights shall, at any time, fail to comply with any of the provisions and requirements of the Act, or with any of the stipulations and conditions that may be prescribed as aforesaid by the Chief of Engineers and the Secretary of War.

Punishment for noncompliance with orders, etc.

SEC. 5. That any persons who shall fail or refuse to comply with the lawful order of the Secretary of War and the Chief of Engineers, made in accordance with the provisions of this Act, shall be deemed guilty of a violation of this Act, and any persons who shall be guilty of a

violation of this Act shall be deemed guilty of a misdemeanor and on conviction thereof shall be punished by a fine not exceeding five thousand dollars, and every month such persons shall remain in default shall be deemed a new offense and subject such persons to additional penalties therefor; and in addition to the penalities above described the Secretary of War and the Chief of Engineers may, upon refusal of the persons owning or controlling any such dam and accessory works to comply with any lawful order issued by the Secretary of War or Chief of Engineers in regard thereto, cause the removal of such dam and accessory works as an obstruction to navigation at the expense of the persons owning or controlling such dam, and suit for such expense may be brought in the name of the United States against such persons, and recovery had for such expense in any court of competent jurisdiction; and the removal of any structures erected or maintained in violation of the provisions of this Act or the order or direction of the Secretary of War or Chief of Engineers made in pursuance thereof may be enforced by injunction, mandamus, or other summary process, upon application to the circuit court in the district in which such structure may, in whole or in part, exist, and proper proceedings to this end may be instituted under the direction of the Attorney-General of the United States at the request of the Chief of Engineers or the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to navigation created by the construction of any dam under this Act, the cause or question arising may be tried before the circuit court of the United States in any district in which any portion of said obstruction or dam touches.

Removal, etc.

Litigation.

SEC. 6. That whenever Congress shall hereafter by law authorize the construction of any dam across any of the navigable waters of the United States, and no time for the commencement and completion of such dam is named in said Act, the authority thereby granted shall cease and be null and void unless the actual construction of the dam authorized in such Act be commenced within one year and completed within three years from the date of the passage of such Act.

Time of construction.

SEC. 7. That the right to alter, amend, or repeal this Act is hereby expressly reserved as to any and all dams which may be constructed in accordance with the provisions of this Act, and the United States shall incur no liability for the alteration, amendment, or repeal thereof to the owner or owners or any other persons interested in any dam which shall have been constructed in accordance with its provisions.

Right to alter, etc., reserved.

SEC. 8. That the word "persons" as used in this Act shall be construed to import both the singular and the plural, as the case demands, and shall include corporations, companies, and associations.

Meaning of "persons."

Approved, June 21, 1906.

(2)

June 23, 1910. Vol. 36, p. 593.

[H. R. 24375.] [Public, No. 246.]

CHAP. 360.—An Act To amend an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, be, and the same is hereby, amended to read as follows:

Dams. Vol. 34, p. 386, amended.

Regulations governing constructing over navigable waters, extended.

"SECTION 1. That when authority has been or may hereafter be granted by Congress, either directly or indirectly or by any official or officials of the United States, to any persons, to construct and maintain a dam for water power or other purpose across or in any of the navigable waters of the United States, such dam shall not be built or commenced until the plans and specifications for such dam and all accessory works, together with such drawings of the proposed construction and such map of the proposed location as may be required for a full understanding of the subject, have been submitted to the Secretary of War and the Chief of Engineers for their approval, nor until they shall have approved such plans and specifications and the location of such dam and accessory works; and when the plans and specifications for any dam to be constructed under the provisions of this Act have been approved by the Chief of Engineers and by the Secretary of War it shall not be lawful to deviate from such plans or specifications either before or after completion of the structure unless the modification of such plans or specifications has previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *Provided*, That in approving the plans, specifications, and location for any dam, such conditions and stipulations may be imposed as the Chief of Engineers and the Secretary of War may deem necessary to protect the present and future interests of the United States, which may include the condition that the persons constructing or maintaining such dam shall construct, maintain, and operate, without expense to the United States in connection with any dam and accessory or appurtenant works, a lock or locks, booms, sluices, or any other structure or structures which the Secretary of War and the Chief of Engineers or Congress at any time may deem necessary in the interests of navigation, in accordance with such plans as they may approve, and also that whenever Congress shall authorize the construction of a lock or other structures for navigation purposes in connection with such dam, the persons owning such dam shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States free

Approval of Secretary of War and Chief of Engineers.

Changes.

Provisos. Conditions.

Approaches, etc., to locks.

Waterpower.

water power or power generated from water power for building and operating such constructions: *Provided further*, That in acting upon said plans as aforesaid the Chief of Engineers and the Secretary of War shall consider the bearing of said structure upon a comprehensive plan for the improvement of the waterway over which it is to be constructed with a view to the promotion of its navigable quality and for the full development of water power; and, as a part of the conditions and stipulations imposed by them, shall provide for improving and developing navigation, and fix such charge or charges for the privilege granted as may be sufficient to restore conditions with respect to navigability as existing at the time such privilege be granted or reimburse the United States for doing the same, and for such additional or further expense as may be incurred by the United States with reference to such project, including the cost of any investigations necessary for approval of plans and of such supervision of construction as may be necessary in the interests of the United States: *Provided further*, That the Chief of Engineers and the Secretary of War are hereby authorized and directed to fix and collect just and proper charge or charges for the privilege granted to all dams authorized and constructed under the provisions of this Act which shall receive any direct benefit from the construction, operation, and maintenance by the United States of storage reservoirs at the headwaters of any navigable streams, or from the acquisition, holding, and maintenance of any forested watershed, or lands located by the United States at the headwaters of any navigable stream, wherever such shall be, for the development, improvement, or preservation of navigation in such streams in which such dams may be constructed.

Bearing upon improvements to be considered.

Charges for improvements, etc.

Charges for storage reservoirs, etc., constructed.

"SEC. 2. That the right is hereby reserved to the United States to construct, maintain, and operate, in connection with any dam built in accordance with the provisions of this Act, a suitable lock or locks, booms, sluices, or any other structures for navigation purposes, and at all times to control the said dam and the level of the pool caused by said dam to such an extent as may be necessary to provide proper facilities for navigation.

Rights reserved for navigation.

"SEC. 3. That the persons constructing, maintaining, or operating any dam or appurtenant or accessory works, in accordance with the provisions of this Act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise. The persons owning or operating any such dam, or accessory works, subject to the provisions of this Act, shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe, and for failure so to do in any respect shall be deemed guilty of a misdemeanor and subject to a fine of not less than five hundred dollars, and each month of such failure shall constitute a separate

Flowage, etc., damages.

Lights, fishways, etc., to be maintained.

Penalty for failure.

offense and subject such persons to additional penalties therefor.

Forfeiture of rights.

"SEC. 4. That all rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such rights shall, at any time, fail, after receiving reasonable notice thereof, to comply with any of the provisions and requirements of the Act or with any of the stipulations and conditions that may be prescribed as aforesaid by the Chief of Engineers and the Secretary of War, including the payment into the Treasury of the United States of the charges provided for by section one of this Act: *Provided*, That Congress may revoke any rights conferred in pursuance of this Act whenever it is necessary for public use, and, in the event of any such revocation by Congress, the United States shall pay the owners of any dam and appurtenant works built under authority of this Act, as full compensation, the reasonable value thereof, exclusive of the value of the authority or franchise granted, such reasonable value to be determined by mutual agreement between the Secretary of War and the said owners, and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of such properties: *And provided also*, That the authority granted under or in pursuance of the provisions of this Act shall terminate at the end of a period not to exceed fifty years from the date of the original approval of the project under this Act, unless sooner revoked as herein provided or Congress shall otherwise direct: *Provided, however*, That this limitation shall not apply to any corporation or individual heretofore authorized by the United States, or by any State, to construct a dam in or across a navigable waterway, upon which dam expenditures of money have heretofore been made in reliance upon such grant or grants.

Provisos. Revocation when needed for public use.

Termination in fifty years.

Exceptions.

Penalty for noncompliance with orders.

"SEC. 5. That any persons who shall fail or refuse to comply with the lawful order of the Secretary of War and the Chief of Engineers, made in accordance with the provisions of this Act, shall be deemed guilty of a violation of this Act, and any persons who shall be guilty of a violation of this Act shall be deemed guilty of a misdemeanor and on conviction thereof shall be punished by a fine not exceeding five thousand dollars, and every month such persons shall remain in default shall be deemed a new offense and subject such persons to additional penalties therefor; and in addition to the penalties above described the Secretary of War and the Chief of Engineers may, upon refusal of the persons owning or controlling any such dam and accessory works to comply with any lawful order issued by the Secretary of War or Chief of Engineers in regard thereto, cause the removal of such dam and accessory works as an obstruction to navigation at the expense of the persons owning or con-

Removal, etc.

trolling such dam, and suit for such expense may be brought in the name of the United States against such persons and recovery had for such expense in any court of competent jurisdiction. Said provision as to recovery of expense shall not apply wherever the United States has been previously reimbursed for such removal; and the removal of any structures erected or maintained in violation of the provisions of this Act or the order or direction of the Secretary of War or the Chief of Engineers made in pursuance thereof may be enforced by injunction, mandamus, or other summary process, upon application to the circuit court in the district in which such structure may, in whole or in part, exist, and proper proceedings to this end may be instituted under the direction of the Attorney-General of the United States at the request of the Chief of Engineers or the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to navigation created by the construction of any dam under this Act the cause or question arising may be tried before the circuit court of the United States in any district in which any portion of said obstruction or dam touches.

Suits for expense.

Proceeding.

Litigation.

"SEC. 6. That whenever Congress shall hereafter by law authorize the construction of any dam across any of the navigable waters of the United States, and no time for the commencement and completion of such dam is named in said Act, the authority thereby granted shall cease and be null and void unless the actual construction of the dam authorized in such Act be commenced within one year and completed within three years from the date of the passage of such Act.

Time for construction.

"SEC. 7. That the right to alter, amend, or repeal this Act is hereby expressly reserved as to any and all dams which may be constructed in accordance with the provisions of this Act, and the United States shall incur no liability for the alteration, amendment, or repeal thereof to the owner or owners or any other persons interested in any dam which shall have been constructed in accordance with its provisions.

Right to alter, etc., reserved.

"SEC. 8. That the word 'persons' as used in this Act shall be construed to import both the singular and the plural, as the case demands, and shall include corporations, companies, and associations. The word 'dam' as used in this Act shall be construed to import both the singular and plural, as the case demands."

Construction of "persons" and "dam."

Approved, June 23, 1910.

(3)

Apr. 23, 1906.
Vol. 34, p. 130.

[H. R. 15259.]
[Public, No. 119.]

CHAP. 1660.—An Act To authorize the North Mississippi Traction Company to construct dams and power stations on the Bear River on the northeast quarter of section thirty-one, township five, range eleven, in Tishomingo County, Mississippi.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the North Mississippi Traction Company, their successors and assigns, having authority therefor under the laws of the State of Mississippi, may hereafter erect, maintain, and use a dam or dams in or across the Bear River, in the State of Mississippi, at such points on the northeast quarter of section thirty-one, township five, range eleven, in Tishomingo County, Mississippi, as they may elect, for the purpose of erecting, operating, and maintaining power stations and to maintain inlet and outlet races or canals and to make such other improvements on Bear River as may be necessary for the development of water power and the transmission of the same, subject always to the provisions and requirements of this Act and to such conditions and stipulations as may be imposed by the Chief of Engineers and the Secretary of War.

Bear River, Miss.
North Mississippi Traction Company may dam.
Location.

SEC. 2. That detailed plans for the construction and operation of a dam or dams and other appurtenant and necessary works shall be submitted by said North Mississippi Traction Company, their successors and assigns, desiring to construct the same, to the Chief of Engineers and the Secretary of War, with a map showing the location of such dam or other structures, with such topographical and hydrographic data as may be necesasry for a satisfactory understanding of the same, which must be approved by the Chief of Engineers and the Secretary of War before work can be commenced on said dam or dams or other structures; and after such approval of said plans no deviation whatsoever therefrom shall be made without first obtaining the approval of the Chief of Engineers and the Secretary of War: *Provided*, That the constructions hereby authorized do not interfere with the navigation of Bear River: *And provided further*, That said dam or dams and works shall be limited only to the use of the surplus water of the river, not required for the navigation of Bear River, and that no structures shall be built and no operations conducted by those availing themselves of the provisions of this Act which shall injure or interfere with the navigation of Bear River or impair the usefulness of any improvement made by the Government in the interest of navigation.

Secretary of War to approve plans, etc.
Provisos.
Unobstructed navigation.
Restriction.

SEC. 3. That the Government of the United States reserves the right, at any time that the improvement of the navigation of Bear River demands it, to construct, maintain, and operate, in connection with any dam or other

Locks, etc.

works built under the provisions of this Act, suitable lock or locks or any other structures for navigation purposes, and at all times to control such dam or dams or other structures, and the level of the pool caused by such dam or dams, to such an extent as may be necessary to provide facilities for navigation; and whenever Congress shall authorize the construction of such lock or other structures, the person, company, or corporation owning and controlling such dam or dams or other structures shall convey to the United States, under such terms as Congress shall prescribe, titles to such land as may be required for the use of such lock and approaches, and in addition thereto shall grant to the United States, free of cost, the free use of water power for building and operating such constructions: *Provided, also*, That the person, company, or corporation building, maintaining, or operating any dam or dams or other structures under the provisions of this Act shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise, and the nearest State or Federal court shall have jurisdiction to hear suits to determine the amount of compensation for alleged damage. The person, company, or corporation owning or operating any such dam shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe.

Proviso. **Damages.** **Lights, etc.** **Fishways.**

SEC. 4. That all the rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such right shall at any time fail to comply with any of the provisions or requirements of this Act, or with any of the stipulations that may be prescribed by the Chief of Engineers and the Secretary of War, or in case a person, company, or corporation authorized by the laws of the State of Mississippi to erect and maintain a dam and improvements as contemplated by this Act shall fail to begin the erection of said dam and improvements within one year after being so authorized and shall fail to complete the same within three years after obtaining such authority.

Forfeiture. **Time of construction.**

SEC. 5. That the provisions of this Act shall in no manner interfere with or impair the rights of any person, company, or corporation heretofore authorized by Congress to erect a dam or other structures for the development of water power on the Tennessee River.

Prior rights not affected.

SEC. 6. That the right to alter, amend, or repeal this Act is expressly reserved.

Amendment.

Approved, April 23, 1906.

(4)

Feb. 25, 1907.
Vol. 34, p. 929.
[H. R. 21194.]
[Public, No. 115.]

CHAP. 1192.—An Act To authorize J. F. Andrews, J. W. Jourdan, their heirs, representatives, associates, and assigns, to construct dams and power stations on Bear River, on the southeast quarter of section thirty-one, township five, range eleven, in Tishomingo County, Mississippi.

Bear River.
J. F. Andrews et al. may construct dam across, in Tishomingo County, Miss.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That J. F. Andrews, J. W. Jourdan, their heirs, representatives, associates, and assigns may hereafter erect, maintain, and use a dam or dams in or across the Bear River, in the State of Mississippi, at such points on the southeast quarter of section thirty-one, township five, range eleven, in Tishomingo County, Mississippi, as they may elect, for the purpose of erecting, operating, and maintaining power stations, and to maintain inlet and outlet races or canals, and to make such other improvements on Bear River as may be necessary for the development of water power and the transmission of the same, in accordance with the provisions of the Act of Congress entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six: *Provided*, That this Act shall in no manner interfere with or impair the rights of any person, company, or corporation heretofore authorized by Congress to erect a dam or other structure for the development of water power on Bear River.

Vol. 34, p. 386.
Proviso.
Restriction.

Amendment.

SEC. 2. That the right to alter, amend, or repeal this Act is expressly reserved.

Approved, February 25, 1907.

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(5)

March 16, 1908.
Vol. 35, p. 45.
[H. R. 16746.]
[Public, No. 59.]

CHAP. 91.—An Act To authorize T. H. Friel or assigns to construct a dam across Mulberry Fork of the Black Warrior River.

Mulberry Fork of Black Warrior River, Ala.
T. H. Friel may dam.
Location.
Vol. 34, p. 386.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That T. H. Friel or assigns be, and they are hereby, authorized to construct, maintain, and operate a dam across the Mulberry Fork of the Black Warrior River, at a point within ten miles north and within two miles south of its junction with the Sipsey Fork, in Walker County, in the State of Alabama, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Amendment.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 16, 1908.

CHAP. 41.—An Act To improve navigation on Black Warrior River, in the State of Alabama.

August 22, 1911. Vol. 37, p. —. [S. 943.] [Public, No. 40.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized, in his discretion, to change the detailed plans and specifications for the construction of Lock and Dam Seventeen, on the Black Warrior River, Alabama, so as to increase the height of the pool level over the dam crest of Lock Seventeen to a height of sixty-three feet above the pool level of Lock Sixteen, so as to render unnecessary the building of Locks Eighteen and Nineteen, as now authorized, and so as to provide for the extension of slack water up the Mulberry and Locust Forks of the Black Warrior River to Sanders Shoals and Nichols Shoals, respectively, and for the development of water power.

Black Warrior River, Ala. Change authorized in plans for Lock and Dam 17.

SEC. 2. That the Secretary of War is hereby authorized and directed to have prepared such detailed plans and estimates as may be necessary to carry into effect the purposes of this Act, and he is further authorized in his discretion to suspend operations during his investigations and to enter into supplemental agreements with the present contractors for Lock and Dam Seventeen, providing for the annulment of existing contracts or for their modification so as to cover the work required for the construction of the higher lock and dam, as he may deem most advantageous for the interests of the United States.

Detailed plans, etc., to be prepared.

Suspension of work.

SEC. 3. Should the construction of the higher dam at site seventeen be found advisable the appropriations and authorizations heretofore made for the cost of locks and dams on the Black Warrior, Warrior, and Tombigbee Rivers, Alabama, shall be available for the construction of Dam Seventeen and such locks as may be necessary to overcome the lift between the pools created by Dams Sixteen and Seventeen.

Use of appropriations if changes advisable. Vol. 35, pp. 359, 998. Vol. 36, pp. 646, 729, 742, 1406.

Approved, August 22, 1911.

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(6)

CHAP. 57.—An Act To authorize the Cahaba Power Company, a corporation organized under the laws of the State of Alabama, to construct a dam across the Cahaba River, in said State, at or near Centerville, Alabama.

March 6, 1908. Vol. 35, p. 37. [H. R. 16051.] [Public, No. 38.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Cahaba Power Company, a corporation organized under the laws of Alabama, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Cahaba River at Centerville, in the State of Alabama, in accordance

Cahaba River. Cahaba Power Company may dam, at Centerville, Ala.

Vol. 34, p. 386. with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Amendment. SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 6, 1908.

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(7)

Apr. 5, 1906. Vol. 34, p. 102. CHAP. 1367.—An Act Authorizing the Choctawhatchee Power Company to erect a dam in Dale County, Alabama.

[H. R. 14808.] [Public, No. 84.]

Choctawhatchee River. Choctawhatchee Power Company may dam, near Newton, Ala.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Choctawhatchee Power Company, its successors and assigns, be, and is hereby, authorized to erect, build, have, and maintain a steel and concrete dam, or dam of other material, on the Choctawhatchee River at a point above the Atlantic Coast Line Railroad bridge near Newton, on said river and in Dale County, Alabama:

Provisos. Secretary of War to approve plans, etc. *Provided*, That the plans of said dam shall be submitted to and be approved by the Chief of Engineers and the Secretary of War before construction is commenced; and the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications in the construction of said dam as he may deem advisable in the interests of navigation: *Provided further*, That there shall be placed and maintained in connection with said

Sluiceway. dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll

Fishways. or charges; and suitable fishways, to be approved by the United States Fish Commission, shall be constructed and maintained on said dam.

Time of completion. SEC. 2. That this Act shall be null and void unless the dam herein authorized is commenced within one year and completed within three years from the date hereof.

Amendment. SEC. 3. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, April 5, 1906.

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(8)

March 10, 1908. Vol. 35, p. 40. CHAP. 77.—An Act To authorize A. J. Smith and his associates to erect a dam across the Choctawhatchee River in Dale County, Alabama.

[H. R. 6195.] [Public, No. 47.]

Choctawhatchee River. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That Andrew J. Smith and his associates, their

successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Choctawhatchee River about one-eighth of a mile below or west of the bridge across said river on the road known as the Newton and Ozark public road, in Dale County, in the State of Alabama, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Andrew J. Smith et al. may dam. Location.

Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, March 10, 1908.

CHAP. 57.—An Act Extending the provisions of the act approved March tenth, nineteen hundred and eight, entitled "An Act to authorize A. J. Smith and his associates to erect a dam across the Choctawhatachee River in Dale County, Alabama."

Feb. 13, 1911. Vol. 36, p. 905.

[S. 10824.] [Public, No. 361.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for completing the construction of the dam authorized by the Act entitled "An Act to authorize A. J. Smith and his associates to erect a dam across the Choctawhatchee River, in Dale County, Alabama," approved March tenth, nineteen hundred and eight, is hereby extended to one year from and after the passage of this Act.

Choctawhatchee River. Time extended for damming, by A. J. Smith et al. Vol. 35, p. 40, amended.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 13, 1911.

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(9)

CHAP. 79.—An Act To authorize the Chucawalla Development Company to build a dam across the Colorado River at or near the mouth of Pyramid Canyon, Arizona; also a diversion intake dam at or near Black Point, Arizona, and Blythe, California.

Feb. 15, 1911. Vol. 36, p. 909.

[H. R. 31859.] [Public, No. 374.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chucawalla Development Company, a corporation organized under the laws of the State of California, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Colorado River at the mouth of Pyramid Canyon, known as "Bulls Head damsite," about twenty-two miles north of Fort Mohave, Mohave County, Arizona, and a portion of said site being located in Lincoln County, Nevada; also a diversion intake dam, ten feet high, to be located at or near Black Point, about twenty miles north and upstream from the town of Ehrenburg, Yuma County, Arizona, and about twenty miles north

Colorado River. Chucawalla Development Co. may dam, at mouth of Pyramid Canyon.

Diversion intake dam at Black Point, Ariz.

Construction. Vol. 34, p. 386.

and above the town of Blythe, Riverside County, California, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six": *Provided*, That the actual construction of said dams shall be begun within two years and completed within five years from the date of the passage of this act: *And provided further*, That the actual construction of said dams shall not be commenced until the plans and specifications therefor shall have been presented to and approved by the Secretary of the Interior in addition to the requirements of the act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six," and in approving the plans and specifications, the Secretary of the Interior may impose such conditions as to him shall seem proper for the protection of the public interests of Indians and the United States.

Provisos. Time for construction.

Secretary of Interior to approve plans, etc.

Indian rights, etc.

Amendment.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 15, 1911.

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(10)

Mar. 3, 1911. Vol. 36, p. 1081.

[S. 10808.] [Public, No. 464.]

CHAP. 220.—An Act To authorize the Greeley-Arizona Irrigation Company to build a dam across the Colorado River at or near Head Gate Rock, near Parker, in Yuma County, Arizona.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Greeley-Arizona Irrigation Company, a corporation organized under the laws of Arizona, is hereby authorized to construct, maintain, and operate a diversion dam in and across the Colorado River at a place known as Head Gate Rock, near Parker, Yuma County, in the Territory of Arizona, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six": *Provided*, That the actual construction of said dam shall be begun within two years and completed within four years from the date of the passage of this Act: *And provided further*, That the actual construction of said dam shall not be commenced until the plans and specifications therefor shall have been presented to and approved by the Secretary of the Interior in addition to the requirements of the Act approved June twenty-third, nineteen hundred and ten, entitled

Colorado River. Greeley-Arizona Irrigation Co. may dam, near Parker, Ariz. Vol. 36, p. 593.

Vol. 34, p. 386.

Provisos. Time of construction.

Approval of plans, etc.

"An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six," and, in approving the plans and specifications, the Secretary of the Interior may impose such conditions as to him shall seem proper for the protection of the public interests of Indians and the United States. Vol. 36, p. 593.

SEC. 2. That the right to alter, amend, or repeal this Act is expressly reserved. Amendment.

Approved, March 3, 1911.

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(11)

CHAP. 2438.—An Act To authorize the construction of dams and power stations on the Coosa River at Lock Two, Alabama.

May 9, 1906.
Vol. 34, p. 183.
[H. R. 15334.]
[Public, No. 150.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any riparian owner, whether person, company, or corporation having authority therefor under the laws of the State of Alabama may hereafter erect, maintain, and use a dam or dams in or across the Coosa River, in the State of Alabama, at such points at or near Lock Two as they may elect and the Secretary of War may approve, between a point on the eastern side of the river in the abandoned portion thereof at a point below the United States Government dam at Lock Two and above the navigable portion of the river between Locks Two and Three, for the purpose of erecting, operating, and maintaining power stations and to maintain inlet and outlet races or canals and to make such other improvements on the eastern bank of the Coosa River between the two points above mentioned as may be necessary for the development of water power and the transmission of the same, subject always to the provisions and requirements of this Act and to such conditions and stipulations as may be imposed by the Chief of Engineers and the Secretary of War for the protection of navigation and the property and other interests of the United States.

Coosa River, Ala.
Right to dam, etc., near Lock 2, granted.
Location.

SEC. 2. That detailed plans for the construction and operation of a dam or dams and other appurtenant and necessary works shall be submitted by the person, company, or corporation desiring to construct the same to the Chief of Engineers and the Secretary of War, with a map showing the location of such dam or other structures, with such topographical and hydrographic data as may be necessary for a satisfactory understanding of the same, which must be approved by the Chief of Engineers and the Secretary of War before work can be commenced on said dam or dams or other structures; and after such approval of said plans, no deviation whatsoever therefrom shall be made without first obtaining the approval of

Secretary of War to approve plans, etc.

Provisos.
Unobstructed navigation.
Restricted use of water.

the Chief of Engineers and the Secretary of War: *Provided*, That the constructions hereby authorized do not interfere with the navigation of the Coosa River: *And provided further*, That said dam or dams and works shall be limited only to the use of the surplus water of the river, not required for the navigation of the Coosa River, and that no structures shall be built and no operations conducted by those availing themselves of the provisions of this Act which shall injure or interfere with the navigation of said river or impair the usefulness of any improvement made by the Government in the interest of navigation.

Locks, etc.

SEC. 3. That the Government of the United States reserves the right, at any time that the improvement of the navigation of the Coosa River demands it, to construct, maintain, and operate, in connection with any dam or other works built under the provisions of this Act, suitable lock or locks or any other structures for navigation purposes, and at all times to control such dam or dams or other structures, and the level of the pool caused by such dam or dams, to such an extent as may be necessary to provide facilities for navigation; and whenever Congress shall authorize the construction of such lock or other structures, the person, company, or corporation owning and controlling such dam or dams or other structures shall convey to the United Staes, under such terms as Congress shall prescribe, titles to such land as may be required for the use of such lock and approaches, and in addition thereto shall grant to the United States, free of cost, the free use of water power for building and operating such constructions: *Provided also*, That the person, company, or corporation building, maintaining, or operating any dam or dams or other structures under the provisions of this Act shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise, in a court of competent jurisdiction: *Provided further*, That any injury or damage to the navigable capacity of the Coosa River, or to the works of improvement of the United States in the said river which may result from the construction of the dam and other works herein authorized, or any alteration, enlargement, or change in said works of improvement which may, in the judgment of the Secretary of War, be made necessary by the construction of said dam and other works, shall be made good and completed at once by those availing themselves of the provisions of this Act, their executors, successors, and assigns, and failing this, such injury or damage may be remedied, and such alteration, enlargement, or change may be completed by the United States, and the cost of the work so required shall be paid by the grantees, their heirs or assigns, and to secure the payment for any work thus done by the United States a bond with good and sufficient security in a sum judged

Conveyance of titles.
Damages.
Injury to navigation.
Failure to repair damages.
Payment for repairs, etc.
Bond.

adequate by the Secretary of War for the payment of the costs of said work shall be executed and filed with the Secretary of War before any advantage shall be taken of the provisions of this Act. The person, company, or corporation owning or operating any such dam shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe.

Lights, etc.

SEC. 4. That all the rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such rights shall at any time fail to comply with any of the provisions or requirements of this Act, or with any of the stipulations that may be prescribed by the Chief of Engineers and the Secretary of War, or in case a person, company, or corporation authorized by the laws of the State of Alabama to erect and maintain a dam and improvements as contemplated by this Act shall fail to begin the erection of said dam and improvements within two years after being so authorized and shall fail to complete the same within five years after obtaining such authority.

Rights to cease on failure to comply with requirements, etc.

Time of construction.

SEC. 5. That the provisions of this Act shall in no manner interfere with or impair the rights of any person, company, or corporation heretofore authorized by Congress to erect a dam or other structures for the development of water power on the Coosa River.

Prior rights not affected.

SEC. 6. That the right to alter, amend, or repeal this Act is expressly reserved.

Amendment.

Approved, May 9, 1906.

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(12)

CHAP. 2577.—An Act Authorizing the use of the waters in Coosa River at Lock Numbered Four, in Alabama.

June 4, 1906. Vol. 34, p. 211.

[H. R. 19473.] [Public, No. 196.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized and empowered to enter into contract with any individual or corporation, private or municipal, preference being given to riparian owners and their assigns, hereinafter designated "the contracting party," to complete the dam and forebay of the lock which has been partially constructed by the Government at Lock Numbered Four on the Coosa River, the work to be done under his supervision and control, and in accordance with the present adopted project and any modification thereof that he may deem proper: *Provided*, That the contracting party shall furnish all materials, of every character, and pay for all labor required in the construction of said dam and forebay, which, upon completion, shall become the property of the United States, free of all costs, claims, or charges

Coosa River, Ala. Completion of Lock No. 4 by private parties authorized.

Provisos. Conditions.

Protection to navigation.

of any kind whatsoever: *Provided further*, That the terms of this Act and any stipulations which the Secretary of War may deem necessary to safeguard the interests of navigation and other interests of the United States shall be embodied in any contract entered into as aforesaid.

Time of completion.

SEC. 2. That the contracting party shall begin the said work within two years from the passage of this Act and shall complete the same within four years from the date of commencing construction, and the Secretary of War may, upon reasonable diligence of the contracting party being shown, extend the time for completion, the Government reserving the right to commence and finish the work, if deemed advisable, at any time before it is com-

Failure to complete.

menced by the contracting party; or, if begun and not carried out in strict conformity to the directions of the Secretary of War, the Government may assume the completion of said work at its option, the cost of such comple-

Proviso. Secretary of War to approve the work.

tion to be paid by the contracting party: *Provided*, That the Secretary of War shall determine from time to time whether the work is being properly done.

Contractors granted use of water power.

SEC. 3. That in consideration of the completion of said dam and forebay, including buttresses and gates, free of cost to the Government, the contracting party is hereby granted such rights as the Government possesses to use the water power produced by said dam for manufacturing and other industrial purposes for a period of ninety-nine

Provisos. Plans.

years: *Provided*, That the plans for the necessary works and structures to utilize said water power shall be approved by the Secretary of War: *Provided further*, That the right is reserved to the United States to construct,

Lock.

maintain, and operate a lock for navigation purposes in connection with said dam and forebay, and nothing shall be done in the use of the water from said dam or otherwise to interfere with or in any way impede or retard the operation of said lock or the proper and complete navigation of the river at all times, nor in any way to interfere with the use and control of the same by the United States or the maintainance [*sic*] of the water surface above the dam at the established pool level; and the Sec-

Regulations.

retary of War is hereby authorized to prescribe regulations to govern the use of the said water power and the operations of the plant and force employed in connection therewith; and no claim shall be made against the United States for any failure of water power, resulting from any

Free use of electric current by the United States.

cause whatsoever: *Provided further*, That the contracting party shall furnish to the United States, free of cost, such electric current as may be necessary for operating the Government lock, in case the same shall be built, and

Right of ingress and egress.

lighting its buildings and grounds: *And provided further*, That the contracting party may have ingress and egress over Government lands in the construction and operation of plant.

SEC. 4. That the Secretary of War may require the contracting party to execute a bond, with proper securities, before the commencement of the work, in such amount as he may consider necessary, to insure the beginning, prosecution, and completion of the work and compliance with the terms and requirements of this Act, and in case of failure to comply with the requirements of said bond the contracting party shall forfeit to the United States the full amount thereof: *Provided*, That a suitable force of inspectors shall be employed on the work by the Secretary of War, at the expense of the United States, to see that the plans and specifications and the terms and requirements of the Act and the conditions of the contract are strictly carried out, and any expense incurred by the United States in maintaining said inspectors shall be paid from any funds available pertaining to the appropriations made by Congress for examinations, surveys, and contingencies of rivers and harbors.

Bond.

Forfeiture.

Proviso. Inspection.

Expense.

SEC. 5. That Congress reserves the right to revoke the rights and privileges conferred by this Act; but in the event of such revocation the United States shall pay to the contracting party, as full compensation, the reasonable value, exclusive of any franchise that may be required under this Act, of all properties erected and lands purchased by them, necessary for the enjoyment of the benefits hereby conferred, such value to be determined by mutual agreement between the Secretary of War and the owners of said properties, and in case they can not agree, then by proceedings in condemnation, to be instituted in the proper United States court: *Provided*, That to insure compliance with the terms of the contract, or to protect the interests of navigation and other interests of the United States, the Secretary of War shall have power, at any time before or after the completion of the work, to order a suspension of all privileges granted by this Act, and compliance with such order may be enforced by injunction of the court of the United States exercising jurisdiction in the district in which the work is situated, and proper proceedings to this end shall be instituted by the Attorney-General upon request of the Secretary of War.

Revocation of rights reserved.

Reimbursement for improvements, etc.

Proviso. Suspension of privileges.

SEC. 6. That nothing in this Act shall be construed as in any way abridging the exclusive jurisdiction and control by the United States over the Coosa River, and of any structures therein, nor as repealing or modifying any of the provisions of law now existing for the protection of navigation.

Jurisdiction.

Existing law not affected.

Approved, June 4, 1906.

(13)

Mar. 4, 1907. Vol. 34, p. 1288.

CHAP. 2912.—An Act Permitting the erection of a dam across Coosa River, Alabama, at the place selected for Lock Numbered Twelve on said river.

[S. 8526.] [Public, No. 247.]

Coosa River, Ala.

Alabama Power Co. may dam.

Location.

Vol. 32, p. 358.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Alabama Power Company, a corporation organized under the laws of the State of Alabama, its successors and assigns, to build a dam, of such height as the Chief of Engineers and the Secretary of War may approve, across the Coosa River, in Alabama, at the place selected for the location of Lock and Dam Numbered Twelve on said river, as located in the survey made by the engineers of the United States of the Coosa and Alabama rivers in Georgia and Alabama, in compliance with the requirements of the river and harbor Act approved June thirteenth, nineteen hundred and two, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed: *Provided*, That plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *Provided further*, That the Alabama Power Company, its successors or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and Secretary of War: *Provided further*, That said dam and appurtenant works shall be limited to the use of the surplus water only of the river not required for the navigation of the Coosa River, and that no structure shall be built and no operations conducted under the provisions of this Act which shall at any time injure or interfere with the navigation of said river or impair the usefulness of any improvement by the Government in the interests of navigation.

Provisos.

Secretary of War to approve plans, etc.

Changes.

Unobstructed navigation.

Locks.

SEC. 2. That the said dam shall be so constructed, including a proper forebay, that the Government of the United States may at any time construct in connection therewith a suitable lock or locks for navigation purposes, and may at any time, without compensation, control the said dam or other structures and the level of the pool caused by such dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of

the owners, such modifications and changes in the construction of such dam as may be neccessary in the interest of navigation: *Provided*, That the Alabama Power Company, its successors or assigns, shall furnish the necessary electric current, while its power plant is in operation, to move the gates and operate the locks in connection with said dam and to light the United States buildings and grounds free of cost to the United States: *Provided further*, That the Alabama Power Company, its successors or assigns, is hereby granted the right to use any lands which may belong to the United States of America and necessary for the construction and maintenance of said dam and appurtenant works, or which may be inundated with water by reason of the construction of said dam and appurtenant works, and in consideration therefor the said company, its successors or assigns, shall, upon request of the Chief of Engineers and the Secretary of War, convey fre of cost to the United States of America such suitable tract or tracts of land as may be selected by the Chief of Engineers and the Secretary of War for the establishment of such lock or locks and approaches and other purposes as the needs of navigation may require.

Changes.

Provisos.

Electric power.

Use of lands for construction, etc.

Conveyance of other lands to the United States.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within three years and completed within seven years from the time of the passage of this Act.

Time of construction.

SEC. 4. The authority herein conferred shall, except as herein specifically provided, be subject in all respects to the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Vol. 34, p. 386.

SEC. 5. The right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, March 4, 1907, 10 a. m.

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(14)

[Extract from river and harbor act of February 27, 1911.]

Feb. 27, 1911.

Vol. 36, p. 939.

[H. R. 28632.]

[Public, No. 425.]

Improving Coosa River, Georgia and Alabama: Continuing improvement by the completion of lock and dam at Mayos Bar, near Rome, Georgia, one hundred and twenty-one thousand and thirty-nine dollars.

Coosa River, Ga. and Ala.

Mayos Bar.

Improving Coosa River, Georgia and Alabama: Continuing improvement by the construction of a lock in Dam Numbered Four, and by the construction of Dam Numbered Five, in the State of Alabama, one hundred and fifty thousand dollars.

Dams Nos. 4 and 5.

The Secretary of War is hereby authorized and empowered to enter into contract with the Ragland Water Power Company, its successors or assigns, hereinafter

Ragland Water Power Co.

May complete dam, etc., at Lock No. 4.

designated "the contracting party," to complete the dam heretofore partially constructed by the Government at Lock Numbered Four on the Coosa River, the work to be done under his supervision and control, and in accordance with the present adopted project and any modification thereof that he may deem proper: *Provided*, That the contracting party shall furnish all materials, of every character, and pay for all labor required in the construction of said dam, which, upon completion, shall become the property of the United States, free of all costs, claims, or charges of any kind whatsoever: *Provided further*, That the terms of this Act and any stipulation which the Secretary of War may deem necessary to safeguard the interests of navigation and other interests of the United States shall be embodied in any contract entered into as aforesaid. The contracting party shall begin the said work within one year from the approval of this Act, and shall complete the same within three years from the date of commencing construction; otherwise the authorization hereby conferred shall be void and the rights hereby conferred shall cease and be determined, the Government reserving the right to commence and finish the work, if deemed advisable, at any time before it is commenced by the contracting party; or, if begun and not carried out in strict conformity to the directions of the Secretary of War, the Government may assume the completion of said work at its option, the cost of such completion to be paid by the contracting party: *Provided*, That the Secretary of War shall determine from time to time whether the work is being properly done. In consideration of the completion of said dam free of cost to the Government, the contracting party is hereby granted such rights as the Government possesses to use the water power produced by said dam for manufacturing and other industrial purposes for a period of fifty years: *Provided*, That the plans for the necessary works and structures to utilize said water power shall be approved by the Secretary of War: *Provided further*, That the right is reserved to the United States to construct, maintain, and operate a forebay and lock for navigation purposes in connection with said dam, and nothing shall be done in the use of the water from said dam or otherwise to interfere with or in any way impede or retard the operation of said lock or the proper and complete navigation of the river at all times, nor in any way to interfere with the use and control of the same by the United States or the maintenance of the water surface above the dam at the established pool level; and the Secretary of War is hereby authorized to prescribe regulations to govern the use of the said water power and the operations of the plant and force employed in connection therewith; and no claim shall be made against the United States for any failure of water power, resulting from any cause whatsoever: *Provided further*, That the contracting party shall furnish to the United States, free of cost, such

Provisos. To bear all expense.

Navigation, etc., interests protected.

Time of construction, etc.

Water power franchise granted.

Approval of plans.

Rights for navigation purposes reserved.

Regulations, etc.

Electric current to Government works, free of cost.

electric current as may be necessary for operating the Government lock and lighting its buildings and grounds: *And provided further*, That the contracting party may have ingress and egress over Government lands in the construction and operation of the plant. The Secretary of War may require the contracting party to execute a bond, with proper securities, before the commencement of the work, in such amount as he may consider necessary, to insure the beginning, prosecution, and completion of the work and compliance with the terms and requirements of this act, and in case of failure to comply with the requirements of said bond the contracting party shall forfeit to the United States the full amount thereof: *Provided*, That a suitable force of inspectors shall be employed on the work by the Secretary of War, at the expense of the contracting party, to see that the plans and specifications and the terms and requirements of the Act and the conditions of the contract are strictly carried out. Congress reserves the right to alter, amend, or repeal the rights and privileges hereby conferred, and the United States shall incur no liability because of the alteration, amendment, or repeal thereof: *Provided*, That to insure compliance with the terms of this contract, or to protect the interests of navigation and other interests of the United States, the Secretary of War shall have power, at any time, to order a suspension of all privileges hereby granted, and a compliance with such order may be enforced by an injunction of the court of the United States exercising jurisdiction in the district in which the work is situated, and proper proceedings to this end shall be instituted by the Attorney General upon request of the Secretary of War. Nothing herein shall be construed as in any way abridging the exclusive jurisdiction and control by the United States of the Coosa River, and of any structure therein, or as repealing or modifying any of the provisions or laws now existing for the protection of navigation. The contracting party, in consideration of the privileges granted hereby, must, under such regulations as the Secretary of War may require, obligate and bind itself, its successors or assigns, to raise the height of said dam at Lock Numbered Four three feet, and shall stop the leaks above Dam Numbered Four by which water escapes under such dam, so far as the same can be done, and to keep said leaks stopped so far as it is possible so to do. In consideration of making said improvements, the said contracting party shall have the right to raise said dam during low water to such a height as may be necessary to give it a storage basin above the dam, in order that it may develop and operate a water power: *Provided*, That the said storage does not interfere with navigation: *Provided further*, That the said contracting party shall pay all damages incurred by reason of overflowed lands. Beginning with the year nineteen hundred and twenty-five, the contracting party shall pay to the

Easement.

Bond, etc.

Inspectors, etc.

Right to alter, etc.

Authority of Secretary of War.

Jurisdiction not impaired.

Raising height at dam, etc., required.

Storage basin.

Condition.

Overflow damages.

Payment for power.

United States for the power due to the natural flowage of the river the sum of one dollar per ten-hour horsepower per year: *Provided*, That in case the natural flowage of the river is increased at this point by storage reservoirs above this point, the power company shall have the right to lease, for a period not exceeding the life of this authorization, the increased power due to said storage, and shall pay on all power above that due to natural flowage of the river, as increased by local storage at Dam Numbered Four, the sum of one dollar per year for the first five years, two dollars per year for the second five years, and thereafter three dollars per year for each ten-hour horsepower sold or used, or in lieu of above payment may, in the discretion of the Secretary of War, pay its equitable share toward the construction of said reservoir or reservoirs, such share to be determined by the Secretary of War: *Provided*, That the Secretary of War, in his discretion, may readjust such rate of compensation at periods of ten years.

Additional, for increase from reservoirs.

Readjusting rate.

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(15)

June 16, 1906. Vol. 34, p. 296.

[H. R. 17881.] [Public, No. 238.]

CHAP. 3339.—An Act Permitting the building of a dam across the Crow Wing River, between the counties of Morrison and Cass, State of Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to Judd Wright, his heirs or assigns, to construct and maintain across the Crow Wing River a dam, canal, and works necessary incident thereto, for water power and supply purposes, at any point at or near the junction of the Gull River with the Crow Wing River, on section thirty, township one hundred and thirty-three north, range twenty-nine west, fifth meridian, between the counties of Morrison and Cass, in the State of Minnesota: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of construction of the same: *And provided further*, That the said Judd Wright, his heirs or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of such plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, and over said dam without unreasonable delay or hindrance, and without

Crow Wing River, Minn. Judd Wright may dam.

Location.

Provisos. Secretary of War to approve plans, etc.

Restriction.

Sluiceway.

toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam, so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation; and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of said dam as he may deem advisable in the interests of navigation.

Lock.

Changes.

SEC. 2. That suitable fishways, to be approved by the Secretary of Commerce and Labor, shall be constructed and maintained at said dam by the said Judd Wright, his heirs or assigns.

Fishways.

SEC. 3. That in case any litigation arises from the building of said dam or from the obstruction of said river, by said dam or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the State of Minnesota or in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said structures from the operation of the same.

Litigation.

Proviso.
Existing laws not affected.

SEC. 4. That the right to amend, alter, or repeal this Act is hereby expressly reserved, and the same shall become null and void unless the construction of the dam hereby authorized is commenced within one year after the passage of this Act and completed within three years thereafter.

Amendment.
Time of completion.

Approved, June 16, 1906.

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(16)

[Extracts from river and harbor act approved March 3, 1905.]

Mar. 3, 1905.
Vol. 33, p. 1132.
[H. R. 18809.]
[Public, No. 215.]

Improving the upper Cumberland and South Fork rivers, above Burnside, Kentucky: The Cumberland River Improvement Company, a corporation formed and existing under the laws of the State of Kentucky, is authorized and permitted to improve the Cumberland River and its tributaries, including the South Fork, above Burnside, Kentucky, at its own expense, by the construction of necessary locks and dams, under the supervision and pursuant to plans to be submitted to and approved by the Secretary of War, and the power generated by the construction of such locks and dams may be utilized by such

Cumberland River Improvement Company.
May construct locks and dams above Burnside, Ky.

Use of power.

company for commercial and other purposes, under the following express provisions:

Unobstructed navigation. That the use of such power shall in no instance impede or hinder navigation;

Size of locks, etc. That the locks and dams shall be at least equal in size and capacity to other locks and dams constructed on the Cumberland River;

Open to navigation. That they shall be open to all purposes of navigation by the general public, subject to the payment of uniform, reasonable rates of toll by all parties using such waterway, which rates of toll shall be fixed from time to time by the Secretary of War, and shall at no time produce an income greater than six per centum, cumulative interest, on the investment in such locks and dams, after deducting the cost of maintenance and operation, reckoned from the beginning, and based on the total initial cost; such locks and dams to be kept and maintained by such corporation without expense to the Government: *Provided further*, That this franchise shall not be effective unless said corporation shall commence in good faith the construction of such improvement within eighteen months after the completion and operation of lock and dam numbered twenty-one on said river, and shall afford a permanent navigable stage, within the next succeeding five years, of at least six feet in depth, by means of such locks and dams, to the mouth of Rock Castle River;

Toll.

Proviso. Time of construction, etc.

Bond. That said corporation shall file with the Secretary of War, before beginning its construction of such lock and dam, a suitable bond, to be approved by him, conditioned to pay all reasonably prospective damages arising from trespass or overflow or other injury to private rights;

Collection of tolls. Time limit. Operation, maintenance, etc. That the right to collect tolls shall cease at the expiration of forty years from the date of completion of lock and dam numbered twenty-one on said river, and that upon the ceasing of the right to collect tolls the United States may assume the possession, care, operation, maintenance, and management of the lock or locks so constructed, without compensation to any person or persons or corporation, but without in any way impairing the right or ownership of the water power and dams created by said corporation, which shall continue the care and maintenance of such dams without interference on the part of the United States;

Amendment. Congress reserves the right to alter, amend, or repeal any of the provisions of this Act in so far as it relates to this franchise.

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(17)

June 13, 1902. Vol. 32, p. 358. [H. R. 12346.] [Public, No. 154.]

[Extracts from river and harbor act approved June 13, 1902.]

Improving Cumberland River, Tennessee, above Nashville: For the completion of Lock and Dam Numbered One and for maintenance, one hundred and five thousand

dollars. And the Secretary of War is hereby authorized, in his discretion, to grant leases or licenses to the highest responsible bidder for the use of the water power created by said dam, at such a rate and on such conditions and for such periods of time as may seem to him expedient; and he is also authorized, in his discretion, to issue permits for the construction, maintenance, and operation of inlet and outlet canals and other structures, on such plans as he may approve, for the diversion of water aforesaid: *Provided*, That any lease or license so granted shall be limited to the use of the surplus water not required for navigation, and no structures shall be built and no operations be conducted which shall in any manner injure navigation, interfere with the operations of the Government, or impair the usefulness of any improvement made by the Government for the benefit of navigation; and the right of Congress to alter, amend, or repeal the provisions of this paragraph is hereby expressly reserved: *Provided further*, That before leasing or licensing such water privileges, or issuing permits for the construction and operation of such canals, or otherwise disposing of any water power or privilege, the Secretary of War shall first advertise the same in one or more daily papers at Nashville, for sixty days immediately preceding, stating specifically the right or privilege proposed to be leased or conveyed, with its exact limitations, inviting bids for the same, and he may, in his discretion, then lease the same for a specific term of years at so much per year, to be paid semiannually in cash into the Treasury, and the Secretary of War shall reserve the right to reject any or all bids.

Lock and Dam No. 1.
Vol. 32, p. 408.
Lease of water power.

Canals.

Provisos.
Restrictions.

Right to amend, etc., reserved.

Advertising.

Bids.

CHAP. 1299.—An Act To amend an Act entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved June thirteenth, nineteen hundred and two.

June 28, 1902.
Vol 32, p. 408.
[Public, No. 180.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved June thirteenth, nineteen hundred and two, be, and the same is hereby, amended so that the two paragraphs thereof providing for the improvement of the Cumberland River, Tennessee, below Nashville, and of the Cumberland River, Tennessee, above Nashville, shall read as follows:

Cumberland River, Tenn. Improvement of.
Vol. 32, p. 358.

"Improving Cumberland River, Tennessee, below Nashville: For the completion of the lock and dam at Harpeth Shoals and for maintenance, one hundred and eighty thousand dollars.

Lock and dam at Harpeth Shoals.

"Improving Cumberland River, Tennessee, above Nashville: Continuing improvement, and for maintenance, two hundred thousand dollars, of which so much as may be necessary shall be used for the completion of Lock and Dam Numbered One. And the Secretary of War is hereby authorized, in his discretion, to grant leases or licenses to the highest responsible bidder for the use of the water power created by said dam, at such a rate and on such conditions and for such periods of time as may seem to him expedient; and he is also authorized, in his discretion, to issue permits for the construction, maintenance, and operation of inlet and outlet canals and other structures, on such plans as he may approve, for the diversion of the water aforesaid: *Provided*, That any lease or license so granted shall be limited to the use of the surplus water not required for navigation, and no structures shall be built and no operations be conducted which shall in any manner injure navigation, interfere with the operations of the Government, or impair the usefulness of any improvement made by the Government for the benefit of navigation; and the right of Congress to alter, amend, or repeal the provisions of this paragraph is hereby expressly reserved: *Provided further*, That before leasing or licensing such water privileges, or issuing permits for the construction and operation of such canals, or otherwise disposing of any water power or privilege, the Secretary of War shall first advertise the same in one or more daily papers at Nashville, for sixty days immediately preceding, stating specifically the right or privilege proposed to be leased or conveyed, with its exact limitations, inviting bids for the same, and he may, in his discretion, then lease the same for a specific term of years at so much per year, to be paid semiannually in cash into the Treasury, and the Secretary of War shall reserve the right to reject any or all bids."

Lock and Dam No. 1.
Water-power leases, etc.
Permits for construction, etc., of canals.
Provisos.
Protection to navigation.
Proposals.
Payments.

Approved, June 28, 1902.

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(18)

Feb. 5, 1907.
Vol. 34, p. 878.
[H. R. 24275.]
[Public, No. 62.]

CHAP. 467.—An Act Permitting the building of a dam across the Flint River at Porter Shoals.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Albany Power and Manufacturing Company, a corporation organized under the laws of Georgia, its successors and assigns, is hereby authorized to construct and maintain a dam across the Flint River at a point in Dougherty County, Georgia, about one-fourth mile above the Georgia Northern Railway bridge across said river, upon or in the vicinity of Porter Shoals, and all works incident thereto in the utilization of the power

Flint River, Ga.
Albany Power and Manufacturing Company may dam.
Location.

thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six. Vol. 34, p. 386.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, February 5, 1907.

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(19)

CHAP. 3301.—An Act To authorize the Charleston Light and Water Company to construct and maintain a dam across Goose Creek in Berkeley County, in the State of South Carolina.

June 14, 1906. Vol. 34, p. 265.

[H. R. 8410.] [Public, No. 230.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the right, power, and privilege to construct, erect, and maintain a dam across the said Goose Creek is hereby authorized, granted, and given to the said the Charleston Light and Water Company, its successors and assigns: *Provided*, That the said the Charleston Light and Water Company shall be liable for all such damages as may be established in any court of competent jurisdiction by any landowner claiming that his land has been damaged by reason of the erection of the said dam: *And provided further*, That nothing herein shall impair any navigation or other rights of any riparian owner, other than the closing of said creek, by the construction, erection, and maintenance of said dam at said location.

Goose Creek, S. C. Charleston Light and Water Company may dam.

Provisos. Damages.

Riparian rights protected.

SEC. 2. That the right to alter, amend, and repeal this Act, and the right to require the alteration or removal of the structure authorized without any liability on the part of the United States, are hereby expressly reserved.

Amendment. Right to alter, etc., the dam reserved.

Approved, June 14, 1906.

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(20)

CHAP. 150.—An Act To authorize J. W. Vance, L. L. Allen, C. F. Helwig, and H. V. Worley, of Pierce City, Missouri; A. B. Durnil, D. H. Kemp, Sig Soloman, J. J. Davis, S. A. Chappell, and W. M. West, of Monett, Missouri; M. L. Coleman, M. T. Davis, Jared R. Woodfill, junior, J. H. Jarrett, and William H. Standish, of Aurora, Lawrence County, Missouri; and L. S. Meyer, F. S. Heffernan, Robert A. Moore, William H. Johnson, J. P. McCammon, M. W. Colbaugh, and W. H. Schreiber, of Springfield, Greene County, Missouri, to construct a dam across the James River, in Stone County, Missouri, and to divert a portion of its waters through a tunnel into the said river again to create electric power.

Feb. 24, 1911. Vol. 36, p. 929.

[S. 574.] [Public, No. 412.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That J. W. Vance, L. L. Allen, C. F. Helwig, and H. V. Worley, of Pierce City, Missouri; A. B. Durnil, D. H. Kemp, Sig Soloman, J. J. Davis, S. A. Chappell,

James River. J. W. Vance and others may dam, in Big Bend of.

and W. M. West, of Monett, Missouri; M. L. Coleman, M. T. Davis, Jared R. Woodfill, junior, J. H. Jarrett, and William H. Standish, of Aurora, Lawrence County, Missouri; and L. S. Meyer, F. S. Heffernan, Robert A. Moore, William H. Johnson, J. P. McCammon, M. W. Colbaugh, and W. H. Schreiber, of Springfield, Greene County, Missouri, their heirs and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam in the Big Bend of the James River, in section twenty-two, township twenty-three north, range twenty-four west, in the county of Stone and State of Missouri, across the said James River at said point, and to impound thereat in what is known as the Lower Narrows of the Big Bend of the said James River the waters of said river, and by canal and tunnel to divert and conduct across said narrows such portion of the water of said river, through said tunnel into said river again, as may be necessary for electric-power purposes. The construction, maintenance, and operation of the dam herein authorized, as well as the determination of the rights and obligations under the permission granted hereby, shall be in all respects in accordance with and subject to the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Construction, etc.

Vol. 34, p. 386.

Amendment.

SEC. 2. That the right to alter, amend, or repeal this Act in whole or in part is hereby expressly reserved.

Approved, February 24, 1911.

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(21)

June 6, 1892.
Vol. 27, p. 46.
[Public, No. 77.]

CHAP. 92.—An Act Granting to the Topeka Water and Electric Power Company of Kansas the right to erect and maintain a dam or dams across the Kansas River, within Shawnee County, in the State of Kansas.

Topeka Water and Electric Power Co. may dam Kansas River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Topeka Water and Electric Power Company, a corporation created and organized under the laws of Kansas, its successors and assigns, to erect, construct, and maintain a dam or dams across the Kansas River at any suitable place or places within Shawnee County, in the State of Kansas.

Amendment, etc.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 6, 1892.

(22)

CHAP. 15.—An Act To authorize the construction and maintenance of a dam or dams across the Kansas River, within Shawnee County, in the State of Kansas.

Jan. 22, 1894.
Vol. 28, p. 27.
[Public, No. 14.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chicago-Topeka Light, Heat, and Power Company, a corporation organized under the laws of the State of Illinois, its successors and assigns, be, and they are hereby, authorized and empowered to construct and maintain a dam or dams across the Kansas River, at any suitable place or places within the county of Shawnee, in the State of Kansas: *Provided*, That on notice by the Secretary of War that said dam or dams are material obstructions to navigation, said dam or dams shall be at once removed, or suitable lock or locks provided by the owner or owners thereof at his or their expense, so as not to interfere with navigation: *And provided further*, That if after due and sufficient notice in such case the owner or owners of said dam or dams shall neglect or fail to provide suitable lock or locks, or otherwise modify or remove said obstructions, in such manner as the Secretary of War may direct, the said Secretary is hereby authorized and directed to cause suitable lock or locks to be provided, or said obstructions to be removed or modified at the expense of the United States, and to institute proceedings against the person or persons or corporation owning or controlling said dam or dams for the recovery of the expense thereof before the circuit court of the United States in and for the district in which said dam or dams may be located.

Kansas River.
Dam across authorized in Shawnee County.
Provisos.
Removal, etc.
Removal, etc., by Secretary of War.
Recovery of expense.

SEC. 2. That the dam or dams herein provided for shall be commenced within one year from the date of approval of this act and completed within three years, under penalty of the forfeiture of the franchise herein granted.

Commencement and completion.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment, etc.

Approved, January 22, 1894.

(23)

CHAP. 3504.—An Act Making appropriations for the current and contingent expenses of the Indian Department, for fulfilling treaty stipulations with various Indian tribes, and for other purposes, for the fiscal year ending June thirtieth, nineteen hundred and seven.

June 21, 1906.
Vol. 34, pp. 325, 368.
[H. R. 15331.]
[Public, No. 258.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, * * *

That the Secretary of the Interior be, and is hereby, authorized, in his discretion, to exchange the whole of the odd numbered sections and parts thereof in the Klamath Indian Reservation in the State of Oregon, now held in

Railroad grant lands in Klamath Reservation.
Exchange authorized.

private ownership under the final decree and decision of the Supreme Court of the United States, affirming the title of the California and Oregon Land Company thereto, in the suit of the United States against said company as reported in volume one hundred and ninety-two, at page three hundred and fifty-five, of the decisions of said court, and aggregating one hundred and eleven thousand three hundred and eighty-five acres, for other lands not exceeding eighty-seven thousand acres, situate in one or more compact bodies, in townships thirty-one and thirty-two south, of ranges eleven, twelve, and thirteen east in said reservation, said lands so taken in exchange to be selected, subject to the approval of the Secretary of the Interior; and in order to facilitate such exchange and the development of the lands to be so taken thereunder there may also be selected in like manner and as part of the quantity aforesaid other lands in said reservation for the location, construction, and operation of mills and power plants, and with the right to construct railroads, dams, reservoirs, and power-transmission lines, subject to the provisions of existing law and such rules and regulations as the Secretary of the Interior may prescribe thereunder. And when such exchange is effected patents for the lands so selected and approved shall issue therefor.

Power plants, mills, etc.

* * * * *

Approved, June 21, 1906.

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(24)

June 30, 1906. Vol. 34, p. 818.

[H. R. 20173.] [Public, No. 408.]

CHAP. 3939.—An Act To authorize Henry T. Henderson and his associates to divert the waters of Little River in the State of Alabama from the lands of the United States for use of electric light and power plant.

Little River, Ala.

Henry T. Henderson may divert, for power plant at Blanche.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there be, and is hereby, granted unto Henry T. Henderson and associates the right or authority to perpetually divert the waters of Little River from lands owned by the United States of America, and situated in Mays Gulf, in township eight south, range nine east, in the State of Alabama, for the purpose of storing and utilizing said waters in the operation of a water-power plant to be erected at or near Blanche, in Cherokee County, in the State of Alabama, for the generation of electric energy or power, and the sale of electric light and electric power: *Provided*, That the said Henry T. Henderson and associates shall pay to the Secretary of the Interior the reasonable value thereof within six months after the passage of this Act, the value to be fixed by the register and receiver of the land office in the district where said water is located, and on failure to pay for the same the Secre-

Proviso. Payment.

tary of the Interior may, in his discretion, declare forfeited the right to divert said water.

Approved, June 30, 1906.

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(25)

CHAP. 159.—An Act To authorize the Minnesota River Improvement and Power Company to construct dams across the Minnesota River.

Feb. 24, 1911. Vol. 36, p. 932.

[S. 10836.] [Public, No. 421.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Minnesota River Improvement and Power Company, a corporation organized under the laws of the State of Minnesota, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate dams across the Minnesota River at points suitable to the interests of navigation, as follows:

Minnesota River. Minnesota River Improvement & Power Co. may dam.

First. One at or near the outlet of Lake Bigstone, in the counties of Bigstone and Lac qui Parle, Minnesota, and the county of Grant, South Dakota, and in that connection to divert the waters of the Whetstone River into Bigstone Lake.

At outlet of Lake Bigstone.

Second. One at or near the confluence of the Redwood and Minnesota Rivers between the counties of Renville and Redwood, in said State.

Confluence with Redwood River.

Each of said dams are to be constructed, maintained, and operated in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Construction, etc. Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 24, 1911.

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(26)

CHAP. 1474.—An Act Permitting the building of a dam across the Mississippi River near the village of Bemidji, Beltrami County, Minnesota.

Mar. 3, 1905. Vol. 33, p. 1043.

[H. R. 19026.] [Public, No. 207.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to Kirby Thomas, E. J. Swedback, and M. A. Spooner, their heirs, administrators, and assignees, to build a dam across the Mississippi River near the village of Bemidji, between the outlet of Lake Bemidji and Wolf Lake, Beltrami County, in said river, and near the village of

Mississippi River. Dam across, near Bemidji, Minn., authorized.

Bemidji, Beltrami County, Minnesota, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said Kirby Thomas, E. J. Swedback, and M. A. Spooner, their heirs, administrators, and assignees, shall not deviate from such plans after such approval, either before or after the completion of said structure, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of such a dam as he may deem advisable in the interests of navigation: *And provided further*, That suitable fishways and lights, to be approved by the Secretary of Commerce and Labor, shall be constructed and maintained at said dam by Kirby Thomas, E. J. Swedback, and M. A. Spooner, their heirs, administrators, and assignees.

Provisos. Secretary of War to approve plans, etc.

Modifications.

Sluiceway.

Lock.

Fishways, etc.

Litigation.

SEC. 2. That in case any litigation arises from the building of said dam or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the State of Minnesota and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers or to exempt said structures from the operation of same.

Proviso. Existing laws not affected.

Time of construction.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within one year and be completed within three years from the time of the passage of this Act.

Amendment.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, March 3, 1905.

CHAP. 8.—An Act To amend an Act entitled "An Act permitting the building of a dam across the Mississippi River near the village of Bemidji, in Beltrami County, Minnesota," approved March third, nineteen hundred and five.

Feb. 1, 1908. Vol. 35, p. 3. [H. R. 7606.] [Public, No. 8.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time limited in which to complete the dam authorized by the Act entitled "An Act permitting the building of a dam across the Mississippi River near the village of Bemidji, Beltrami County, Minnesota, approved March third, nineteen hundred and five, be, and the same is hereby, extended for a period of one year.

Mississippi River. Time extended for damming, by Kirby Thomas, etc., at Bemidji, Minn. Vol. 33, p. 1044, amended.

Approved, February 1, 1908.

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(27)

CHAP. 2575.—An Act Permitting the building of a dam across the Mississippi River near the city of Bemidji, Beltrami County, Minnesota.

June 4, 1906. Vol. 34, p. 210. [H. R. 18026.] [Public, No. 194.]

Be it enacted by the Senate and House of Representatives of the United States of American in Congress assembled, That the consent of Congress is hereby granted to William R. Morrison and H. W. Haines to build a dam across the Mississippi River near the city of Bemidji, Minnesota, between the point where the same crosses the west line of township one hundred and forty-five, range thirty-five, and the point where said river crosses the north line of said township in Hubbard County, Minnesota, for the development of water power and such works and structures in connection therewith as may be necessary or convenient in the development of such power and in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said William R. Morrison and H. W. Haines, their heirs, administrators, and assigns, shall not deviate from such plans after such approval, either before or after the completion of said structure, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway, so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensa-

Mississippi River. William R. Morrison and H. W. Haines may dam, near Bemidji, Minn.

Provisos. Secretary of War to approve plans, etc.

Changes.

Sluiceway.

Lock.

tion, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation; and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of such a dam as he may deem advisable in the interests of navigation: *And provided further*, That suitable fishways and lights, to be approved by the Secretary of Commerce and Labor, shall be constructed and maintained at said dam by William R. Morrison and H. W. Haines, their heirs, administrators, and assigns.

Fishways and lights.

Litigation.

SEC. 2. That in case any litigation arises from the building of said dam or from the obstructions of said river by said dam or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the State of Minnesota and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers or to exempt said structures from the operation of the same.

Existing law not affected.

Time of completion.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within one year and be completed within three years from the time of the passage of this Act.

Amendment.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, June 4, 1906.

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(28)

Apr. 15, 1886.
Vol. 24, p. 12.

CHAP. 49.—An Act To authorize the Mississippi Water-Power and Boom Company, of Brainard [Brainerd], Minnesota, to construct a dam across the Mississippi River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of the Government is hereby given to the Mississippi Water-Power and Boom Company of Brainard, Minnesota, to construct across the Mississippi River, at some point not more than two miles from the limits of said city of Brainard, to be approved by the Secretary of War, a dam, canal and the appurtenances thereof, for water-power and other purposes, and in connection therewith a wagon and foot bridge for public travel: *Provided*, That the Government of United States may at any time construct in connection therewith a suitable lock for navigation purposes: *Provided also*, That the Government of the United States may at any time take possession of said dam and control

Dam across Mississippi River may be built by Mississippi Water-Power and Boom Co., of Brainerd, Minn.

Canal and bridge.

Provisos.

Lock.

Government may take possession.

the same for purposes of navigation, by paying said company the actual cost of the same, but shall not do so to the destruction of the water-power created by said dam: *Provided further*, That the Secretary of War may at any time require and enforce, at the expense of the owners, such modification and changes in the construction of said dam as he may deem advisable in the interests of navigation; and that said dam shall, if necessary, be so built that boats and rafts may pass through the same, without the imposition of any toll or charge: *And provided further*, That all suits relative to any obstruction of navigation arising from said dam may be tried in the United States circuit and district courts for Minnesota.

Navigation.

Litigation.

SEC. 2. That the right to alter, amend, or repeal this act is hereby expressly reserved without any claim of any kind arising in favor of any party in consequence of such amendment or repeal.

Right to amend, etc., reserved.

Approved, April 15, 1886.

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(29)

CHAP. 3302.—An Act Permitting the building of a dam across the Mississippi River at or near the village of Clearwater, Wright County, Minnesota.

June 14, 1906. Vol. 34, p. 266.

[H. R. 17455.] [Public, No. 231.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to The Mississippi River Power Company, a corporation organized under the laws of the State of Minnesota, its successors and assigns, to build a dam across the Mississippi River above the mouth of Clearwater River, at or near the village of Clearwater, Wright County, Minnesota, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That The Mississippi River Power Company, its successors or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance

Mississippi River.

The Mississippi River Power Co. may dam, at Clearwater, Minn.

Vol. 34, p. 1235.

Provisos.

Secretary of War to approve plans, etc.

Modification of plans.

Sluiceway

Lock. and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of such dam as he may deem advisable in the interests of navigation: *And provided further*, That suitable fishways, to be approved by the Secretary of Commerce and Labor, shall be constructed and maintained at said dam by The Mississippi River Power Company, its successors or assigns.

Control of dam by United States.

Changes.

Fishways.

Litigation. SEC. 2. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts, as now provided for that purpose in the State of Minnesota and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers or to exempt said structures from the operation of same.

Existing laws not affected.

Time of construction. SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within one year and completed within three years from the time of the passage of this Act.

Amendment. SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, June 14, 1906.

Mar. 2, 1907. Vol. 34, p. 1235.

[H. R. 25717.] [Public, No. 205.]

CHAP. 2546.—An Act To amend an Act entitled "An Act permitting the building of a dam across the Mississippi River at or near the village of Clearwater, Wright County, Minnesota," approved June fourteenth, nineteen hundred and six.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across the Mississippi River at or near the village of Clearwater, Wright County, Minnesota," approved June fourteenth, nineteen hundred and six, be, and the same hereby is, amended so as to read as follows:

Mississippi River. Time extended for dam, at Clearwater, Minn.

"SEC. 3. That this Act shall be null and void unless the construction of the dam hereby authorized is commenced within one year from June fourteenth, nineteen hundred and seven, and completed within three years thereafter."

Time of construction. Vol. 34, p. 267, amended.

Approved, March 2, 1907.

(30)

CHAP. 30.—An Act Granting to the Des Moines Rapids Power Company the right to erect, construct, operate, and maintain a wing dam, canal, and power station in the Mississippi River in Hancock County, Illinois.

Feb. 24, 1894. Vol. 28, p. 38. [Public, No. 28.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Des Moines Rapids Power Company, a corporation created and organized under the laws of the State of Illinois, its successors and assigns, to erect, construct, operate, and maintain a canal along the east bank of the Mississippi River, between Nauvoo and Hamilton, in Hancock County, in the State of Illinois, to erect, construct, operate, and maintain a power station thereon, and to project, erect, construct, operate, and maintain a wing dam five hundred feet into the river from the head of said canal, and to make such other improvements as may be necessary within said limit for the development of water power and the generation, use, and transmission thereform [*sic*] of electric energy and power at, in, and upon the Des Moines Rapids of the Mississippi River: *Provided*, That the constructions hereby authorized do not in any way interfere with the existing low-water channel over the Des Moines Rapids, or with any interests of navigation: *And provided further*, That until the plans and locations of the works herein authorized, so far as they affect the interests of navigation, have been approved by the Secretary of War the canal shall not be commenced or built.

Des Moines Rapids Power Co. may build dam, etc., Mississippi River, Ill.

Provisos.

Navigation not obstructed.

Secretary of War to approve plans, etc.

SEC. 2. That this act shall be null and void if actual construction of the works herein authorized be not commenced within two years and completed within four years from the date hereof.

Commencement and completion.

SEC. 3. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Amendment, etc.

Approved, February 24, 1894.

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(31)

CHAP. 346.—An Act Granting to Keokuk and Hamilton Water Power Company right to construct and maintain wing dam, canal, and power station in the Mississippi River in Hancock County, Illinois.

Feb. 8, 1901. Vol. 31, p. 764. [Public, No. 43.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Keokuk and Hamilton Water Power Company, a corporation created and organized under the laws of the State of Illinois, its successors and assigns, to erect, construct, operate, and maintain a canal along the east bank of the Mississippi River, between Nauvoo and Hamilton, in

Keokuk and Hamilton Water Power Co. may dam, etc., Mississippi River in Hancock County, Ill.

Vol. 33, p. 56.

Hancock County, in the State of Illinois, to erect, construct, operate, and maintain a power station thereon, and to project, erect, construct, operate, and maintain a wing dam five hundred feet into the river from the head of the said canal, and to make such other dams and improvements as may be necessary within said limits for the development of water power and the generation, use, and transmission therefrom of electric energy and power at, in, and upon the Des Moines Rapids of the Mississippi River: *Provided*, That the constructions hereby authorized do not in any way interfere with the existing low-water channel over the Des Moines Rapids or with the interests of navigation: *And provided further*, That until the plans and location of the works herein authorized, so far as they affect the interests of navigation, have been approved by the Secretary of War the canal or other improvements shall not be commenced or built.

Provisos. Existing low-water channel, Des Moines Rapids, etc. Approval of plans.

Commencement and completion.

SEC. 2. That this Act shall be null and void if actual construction of the works herein authorized be not commenced within three years and completed within six years from the date hereof.

Amendment.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 8, 1901.

Feb. 26, 1904. Vol. 33, p. 56.

[H. R. 9640.] [Public, No. 32.]

CHAP. 171.—An Act To amend an Act granting to the Keokuk and Hamilton Water Power Company right to construct and maintain a dam, and so forth, approved February eighth, nineteen hundred and one.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act granting to the Keokuk and Hamilton Water Power Company right to construct and maintain wing dam, canal, and power station in the Mississippi River in Hancock County, Illinois, approved February eighth, nineteen hundred and one, be, and it is hereby, amended as follows: In section two of said Act strike out the word "three" and insert the word "four" in lieu thereof; also strike out the word "six" and insert the word "seven" in lieu thereof.

Mississippi River. Time extended for dam, etc., by Keokuk and Hamilton Water Power Co. Vol. 31, p. 764, amended.

Approved, February 26, 1904.

Feb. 9, 1905. Vol. 33, p. 712.

[H. R. 15284.] [Public, No. 65.]

CHAP. 566.—An Act Granting to the Keokuk and Hamilton Water Power Company rights to construct and maintain for the improvement of navigation and development of water power a dam across the Mississippi River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Keokuk and Hamilton Water Power Company, a corporation created and organized under the laws of the State of Illinois, its successors, and assigns, to erect, construct, operate, and maintain a dam, with its crest at an elevation of from thirty to thirty-five feet above standard low water, across the Mississippi River at or near the foot of

Mississippi River. Keokuk and Hamilton Water Power Co. may dam at Des Moines Rapids, Iowa.

the Des Moines Rapids, from Keokuk, Iowa, to Hamilton, Illinois, and to construct, operate, and maintain power stations on or in connection with the said dam, with suitable accessories for the development of water power, and the generation, use, and transmission therefrom of electric energy and power to be derived from the Des Moines Rapids on the Mississippi River: *Provided*, That in lieu of the three locks and the dry dock, with their appurtenances, now owned and operated by the United States, at the Des Moines Rapids Canal, the said Keokuk and Hamilton Water Power Company shall build, coincidentally with the construction of the said dam and appurtenances, at locations approved by the Secretary of War, a lock and dry dock with their appurtenances; the said lock shall be of such a kind and size and shall have such appurtenances and equipment as shall conveniently and safely accommodate the present and prospective commerce of the Mississippi River; the said dry dock and its appurtenances shall be such as to give space, facilities, and conveniences for the repair of vessels at least equal to those afforded by the existing Government dry dock and shops at the Des Moines Rapids Canal: *And provided further*, That the said dam and appurtenant works shall be so designed, located, constructed, maintained, and operated, and the said lock and dry dock, with their appurtenances, shall be so designed, located, constructed and equipped, as to permit at all times during the season of navigation, and at any stage of water, the safe and convenient navigation of steamboats and other vessels, or of rafts and barges, through the portion of the Mississippi River now occupied by the Des Moines Rapids, as well as through the entire length of the pool formed by the said dam: *And provided further*, That detailed plans for the construction and operation of the said dam, lock, dry dock, and appurtenant works, shall be submitted to and approved by the Secretary of War before the commencement of any portion of the said works; and the said works shall be constructed under the supervision of some engineer officer of the Army designated for that purpose, and that after the approval of the said plans no deviation therefrom shall be made without the prior approval of the Secretary of War of any such deviation; *And provided further*, That compensation shall be made by the said Keokuk and Hamilton Water Power Company to all persons, firms, or corporations whose lands or other property may be taken, overflowed, or otherwise damaged by the construction, maintenance, and operation of the said works in accordance with the laws of the State where such lands or other property may be situated; but the United States shall not be held to have incurred any liability for such damages by the passage of this Act: *And provided further*, That when the said dam, lock, dry dock, and appurtenant works shall have been completed to the satisfaction of the Secretary of War, the United States shall have the ownership and control of the

Provisos.
Construction of lock and dry dock, etc.

Restrictions.

Unobstructed navigation.

Secretary of War to approve plans, etc.

Supervision of engineer officer, etc.

Compensation for damages.

Nonliability of the United States.

Operation of lock and dry dock.

said lock, dry dock, and their appurtenances, and operate and maintain the same.

Protection to navigation.

SEC. 2. That the withdrawal of water from the Mississippi River and the discharge of water into the said river, for the purpose of operating the said power stations and appurtenant works, shall be under the direction and control of the Secretary of War, and shall at no time be such as to impede or interfere with the safe and convenient navigation of the said river by means of steamboats or other vessels, or by rafts or barges: *Provided*, That the said company shall construct such suitable fishways as may be required from time to time by the Secretary of Commerce and Labor.

Proviso. Fishways.

Cost of construction, etc.

SEC. 3. That, except as provided for below in this section, the Keokuk and Hamilton Water Power Company shall bear the entire cost of locating, constructing, maintaining, and operating the structures and appurtenances provided for in this Act: *Provided*, That the United States shall bear the cost of the supervision of the work by an engineer officer of the Army as provided for in section one of this Act, and also the cost of maintaining and operating the lock and dry dock with their appurtenances, after their completion and due acceptance by the Secretary of War on behalf of the United States: *And provided further*, That the Keokuk and Hamilton Water Power Company shall provide, in connection with such lock, dry dock, and appurtenances, a suitable power plant for operating and lighting the same, according to plans and specifications submitted to and approved by the Secretary of War.

Provisos. Cost of supervision.

Power plant.

Repeal of former act. Vol. 31, p. 764.

SEC. 4. That the Act entitled "An Act granting to the Keokuk and Hamilton Water Power Company right to construct and maintain wing dam, canal, and power station in the Mississippi River in Hancock County, Illinois," approved February eighth, nineteen hundred and one, is hereby repealed.

Time of construction.

SEC. 5. That this Act shall be null and void if actual construction of the works herein authorized be not commenced within five years and completed within ten years from the date hereof.

Amendment.

SEC. 6. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 9, 1905.

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(32)

Feb. 27, 1899. Vol. 30, p. 904.

[Public, No. 80.]

CHAP. 211.—An Act To authorize the Grand Rapids Water Power and Boom Company, of Grand Rapids, Minnesota, to construct a dam and bridge across the Mississippi River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Grand Rapids Water Power and Boom Company, of

Grand Rapids Water Power and Boom Co. may bridge, etc., Mississippi River at Grand Rapids, Minn.

Grand Rapids, Minnesota, its successors and assigns, to construct across the Mississippi River, at a point within the limits of the village of Grand Rapids, Minnesota, to be approved by the Secretary of War, a dam, canal, and works necessarily incident thereto, for water-power purposes, and a wagon and foot bridge if desired in connection therewith for the purpose of travel. Said dam shall be so constructed that there can at any time be constructed in connection therewith a suitable lock for navigation purposes: *Provided*, That the Government of the United States may at any time take possession of said dam without compensation and control the same for purposes of navigation, but shall not do so to the destruction of the water power created by said dam to any greater extent than may be necessary to provide proper facilities for navigation: *Provided also*, That said dam shall be so constructed that it will not at any time raise the water surface, at a point three hundred feet above said dam, to an elevation higher than the floor of the sluices of the reservoir dam built by the Government at Pokegama Falls on the Mississippi River, in section thirteen, township fifty-five, range twenty-six west of the fourth principal meridian, Minnesota: *Provided further*, That said dam shall be so constructed as to provide for the free passage of saw logs without tolls or charges; and the said company shall construct and maintain, at its own expense, suitable fishways, to be approved by the United States Fish Commissioner; and the said company, its successors and assigns, shall make such change and modification in said dam, canal, and works incident thereto, and said bridge, as the Secretary of War may from time to time deem necessary in the interests of navigation, at its own cost and expense: *Provided further*, That in case any litigation arises from the obstruction of the channel by said dam, canal, and works incident thereto, or such bridge, the case may be tried in the proper court of the United States in the district in which said works are situated.

Vol. 31, p. 33.

Dam, etc., for water-power purposes.

Provisos.

Government control, etc.

Construction, etc.

Passage of saw logs.

Fishways.

Changes.

Litigation.

SEC. 2. That the right to amend, alter, or repeal this Act is hereby expressly reserved.

Amendment.

SEC. 3. That this Act shall be null and void unless said dam herein authorized be commenced within one year and completed within three years from the date hereof.

Commencement and completion.

Approved, February 27, 1899.

CHAP. 26.—An Act To amend an Act entitled "An Act to authorize the Grand Rapids Water Power and Boom Company, of Grand Rapids, Minnesota, to construct a dam and bridge across the Mississippi River," approved February twenty-seventh, eighteen hundred and ninety-nine.

Feb. 27, 1900.

Vol. 31, p. 33.

[Public, No. 26.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act to

Time extended to Grand Rapids Water Power and Boom Co. to dam, etc., Mississippi River at Grand Rapids, Minn.

authorize the Grand Rapids Water Power and Boom Company, of Grand Rapids, Minnesota to construct a dam and bridge across the Mississippi River," approved February twenty-seventh, eighteen hundred and ninety-nine, is hereby amended so as to read as follows:

Vol. 30, p. 904.

"SEC. 3. That this Act shall be null and void unless said dam herein authorized be commenced within two years and completed within four years from the date hereof."

Approved, February 27, 1900.

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(33)

July 3, 1886. Vol. 24, p. 123.

CHAP. 623.—An Act To authorize the improvement of the water-power of the Mississippi River at Little Falls, Minnesota.

Little Falls Water-Power Co., may build dam, etc., at Little Falls, Mississippi River, Minn.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Little Falls Water-Power Company of Minnesota to improve and develop the water-power in the Mississippi River at Little Falls, in the State of Minnesota, by constructing, maintaining, and operating in said river, at said Little Falls, dams, piers, sluice ways, canals, locks, ponds, breakwaters, abutments, and mill sites for manufacturing purposes.

Provisos.

Sluiceway, etc., for passage of logs, etc.

Provided, That there shall be placed and maintained in connection with said dam and other works a sluice-way, lock, or other fixture sufficient and so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam or other works without unreasonable delay or hindrance, and without tolls or charges: *Provided further*, That the Secretary of War may at any time require such changes and alterations to be made in said works, at the expense of said water-power company, as he may deem advisable and necessary in the interest of navigation.

Changes.

SEC. 2. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, July 3, 1886.

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(34)

Mar. 5, 1898. Vol. 30, p. 253.

[Public, No. 28.]

CHAP. 37.—An Act Permitting the building of a dam between Coon Rapids and the north limits of the city of Minneapolis, Minnesota, across the Mississippi River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to

the Twin City Rapid Transit Company, its successors or assigns, to construct across the Mississippi River, at any point between Coon Rapids and the north line of the limits of the city of Minneapolis, a dam, canal, and works necessarily incident thereto, for water-power purposes. The said dam shall be so constructed that there can, at any time, be constructed in connection therewith a suitable lock for navigation purposes: *Provided, also,* That the Government of the United States may at any time take possession of said dam and appurtenant works and control the same for purposes of navigation by paying the said company the value not exceeding the actual cost of the same, but shall not do so to the destruction of the water power created by said dam to any greater extent than may be necessary to provide proper facilities for navigation: *Provided further,* That the works shall be constructed so as to provide for the free passage of saw logs. The said Twin City Rapid Transit Company shall make such change and modification in the works as the Secretary of War may from time to time deem necessary in the interests of navigation, at its own cost and expense: *Provided further,* That in case any litigation arises from the obstruction of the channel by the dam, canal, or appurtenant works, the case may be tried in the proper Federal court of the United States in which the works are situated.

Twin City Rapid Transit Co. may construct dam, etc., across Mississippi River between Coon Rapids and Minneapolis.

Vol. 31, p. 75.

Lock.

Provisos.

Possession by Government, etc.

Passage of saw logs.

Changes.

Litigation to be in Federal court.

SEC. 2. That the right to amend, alter, or repeal this Act is hereby expressly reserved: *And provided further,* That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by the Twin City Rapid Transit Company, its successors or assigns.

Amendment.

Proviso.

Fishways.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within two years and completed within five years from the date hereof.

Commencement and completion.

Approved, March 5, 1898.

CHAP. 189.—An Act Permitting the building of a dam between Coon Rapids and the north limits of the city of Minneapolis, Minnesota, across the Mississippi River.

Apr. 12, 1900.

Vol. 31, p. 75.

[Public, No. 67.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Twin City Rapid Transit Company, its successors or assigns, to construct across the Mississippi River, at any point between Coon Rapids and the north line of the limits of the city of Minneapolis, a dam, canal, and works necessarily incident thereto, for water-power purposes. The said dam shall be so constructed that there can, at any time, be constructed in connection therewith a suitable lock for navigation purposes: *Provided, also,* That the Government of the United States may at any time take possession of said dam and appurtenant works and

Twin City Rapid Transit Co., may dam Mississippi River at Coon Rapids, etc.

Vol. 30, p. 253.

Provisos.

Government control.

control the same for purposes of navigation by paying the said company the value not exceeding the actual cost of the same, but shall not do so to the destruction of the water power created by said dam to any greater extent than may be necessary to provide proper facilities for navigation: *Provided further*, That the works shall be constructed so as to provide for the free passage of saw logs. The said Twin City Rapid Transit Company shall make such change and modification in the works as the Secretary of War may from time to time deem necessary in the interests of navigation, at its own cost and expense: *Provided further*, That in case any litigation arises from the obstruction of the channel by the dam, canal, or appurtenant works, the case may be tried in the proper Federal court of the United States in which the works are situated.

Passage of saw logs.

Changes.

Litigation.

SEC. 2. That the right to amend, alter, or repeal this Act is hereby expressly reserved: *And provided further*, That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by the Twin City Rapid Transit Company, its successors or assigns.

Amendment.

Proviso.

Fishways.

SEC. 3. That this Act shall become null and void unless the dam herein authorized be commenced on or before the first day of July, nineteen hundred and one, and be completed within three years thereafter.

Commencement and completion.

Approved, April 12, 1900.

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(35)

June 25, 1906.
Vol. 34, p. 456.

[S. 6451.]
[Public, No. 282.]

CHAP. 3530.—An Act To provide for a commission to examine and report concerning the use by the United States of the waters of the Mississippi River flowing over the dams between Saint Paul and Minneapolis, Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a commission is hereby created to examine and report to the Secretary of War, for transmission to Congress, concerning the use of the surplus water which shall not be needed for the purposes of navigation flowing over the dams now under construction by the United States in the Mississippi River between the cities of Saint Paul and Minneapolis, Minnesota.

Mississippi River.

Commission to report on use of surplus water, Minnesota.

That such commission shall be composed of one officer of the Corps of Engineers of the United States Army, one officer of the Quartermaster's Department of the United States Army, both of whom shall be designated by the Secretary of War, and one official of the Treasury Department, who shall be an expert in electrical engineering, who shall be designated by the Secretary of the Treasury.

Composition.

SEC. 2. That this commission shall examine and report upon the following propositions: Scope.

First. Whether there will be any surplus water flowing over said dams not needed for the purpose of navigation which might be available for mechanical or commercial power. Use for commercial, etc., power.

Second. Whether such power, or any part thereof, could be economically utilized for furnishing the light and power now needed or which hereafter may be needed in the buildings and property of the United States at Saint Paul, Minneapolis, and Fort Snelling, Minnesota, and, if so, to what extent, and what proportion or amount of the available power could be so utilized by the United States or disposed of in any manner to the advantage of the United States. For Government buildings, etc., St. Paul, Minneapolis, and Fort Snelling.

Third. If it shall appear to said commission feasible and economical for the United States to use or dispose of such power or any part thereof, then said commission shall report a plan or plans, with terms and conditions for such use or disposition, and an estimate of the cost thereof to the United States. Plans for using power.

SEC. 3. That the said commission shall meet at such time and place as may be directed by the Secretary of War, and shall transmit said report within two years after the passage of this Act. Report.

Approved, June 25, 1906.

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(36)

CHAP. 3300.—An Act Permitting the building of a dam across the Mississippi River above the village of Monticello, Wright County, Minnesota.

June 14, 1906. Vol. 34, p. 264. [S. 5357.] [Public, No. 229.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to The Mississippi River Power Company, a corporation organized under the laws of the State of Minnesota, its successors and assigns, to build a dam across the Mississippi River, between the township of Monticello, in Wright County, Minnesota, and the township of Becker, in Sherburne County, Minnesota, and above the village of Monticello, in said Wright County, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That The Mississippi River Power Company, its successors or

Mississippi River, Minn. The Mississippi River Power Company may dam. Location. Vol. 34, p. 1285.

Provisos. Secretary of War to approve plans, etc.

Modification of plans.

assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War:

Sluiceway.

And provided further, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance, and without toll or charges: *And further provided*, That the dam shall be so constructed that the Government of the United States may at any

Lock.

time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without com-

Control of dam by United States.

pensation, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense

Changes.

of the owners, such modifications and changes in the construction of such dam as he may deem advisable in the interests of navigation: *And provided further*, That

Fishways.

suitable fishways, to be approved by the United States Fish Commission, shall be constructed and maintained at said dam by The Mississippi River Power Company, its successors or assigns.

Litigation.

SEC. 2. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts, as now provided for that purpose in the State of Minnesota and in the courts of the

Proviso. Existing laws not affected.

United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said structures from the operation of same.

Time of completion.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within one year and be completed within three years from the time of the passage of this Act.

Amendment.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, June 14, 1906.

Mar. 2, 1907. Vol. 34, p. 1235. [H. R. 25716.] [Public, No. 204.]

CHAP. 2545.—An Act To amend an Act entitled "An Act permitting the building of a dam across the Mississippi River above the village of Monticello, Wright County, Minnesota," approved June fourteenth, nineteen hundred and six.

Mississippi River. Time extended for dam, above Monticello, Minn.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across the Mississippi River above the village of Monticello, Wright County, Minnesota," approved June fourteenth, nineteen hundred

and six, be, and the same is hereby, amended so as to read as follows:

"SEC. 3. That this Act shall be null and void unless the construction of the dam hereby authorized is commenced within one year from June fourteenth, nineteen hundred and seven, and completed within three years thereafter."

Time of construction.
Vol. 34, p. 265, amended.

Approved, March 2, 1907.

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(37)

CHAP. 2574.—An Act Permitting the building of a dam across the Mississippi River in the county of Morrison, State of Minnesota.

June 4, 1906.
Vol. 34, p. 209.
[H. R. 17758.]
[Public, No. 198.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to The Pike Rapids Power Company, a Minnesota corporation, its successors or assigns, to construct and maintain across the Mississippi River a dam, canal, and works necessary incident thereto for water power and supply purposes at any point between section twenty, township one hundred and twenty-eight north, range twenty-nine west, and section seventeen, in township thirty-nine, range thirty-two, in Morrison County, Minnesota: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said The Pike Rapids Power Company, its successors or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modifications of such plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, and over said dam without unreasonable delay or hindrance, and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for the purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the con-

Mississippi River.
The Pike Rapids Power Co. may dam, etc., in Morrison County, Minn.
Vol. 34, p. 1219.

Provisos.
Secretary of War to approve plans, etc.

Changes.

Sluiceway.

Lock.

struction of said dam as he may deem advisable in the interests of navigation.

Fishways.

SEC. 2. That suitable fishways, to be approved by the Secretary of Commerce and Labor, shall be constructed and maintained at said dam by said corporation, its successors or assigns.

Litigation.

SEC. 3. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the State of Minnesota, or in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said structures from the operation of same.

Existing law not affected.

Amendment. Time of completion.

SEC. 4. That the right to amend, alter, or repeal this Act is hereby expressly reserved; and the same shall become null and void unless the construction of the dam hereby authorized is commenced within one year after the passage of this Act and completed within three years thereafter.

Approved, June 4, 1906.

Mar. 2, 1907. Vol. 34, p. 1219.

[S. 8377.] [Public, No. 179.]

CHAP. 2520.—An Act To amend an Act entitled "An Act permitting the building of a dam across the Mississippi River in the county of Morrison, State of Minnesota," approved June fourth, nineteen hundred and six.

Mississippi River. Time extended to The Pike Rapids Power Co. to dam, in Morrison County, Minn.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section one of an Act entitled "An Act permitting the building of a dam across the Mississippi River in the county of Morrison, State of Minnesota," approved June fourth, nineteen hundred and six, be, and the same is hereby, amended so as to read as follows:

Location. Vol. 34, p. 209, amended.

"SECTION 1. That the consent of Congress is hereby granted to the Pike Rapids Power Company, a Minnesota corporation, its successors or assigns, to construct and maintain across the Mississippi River a dam, canal, and works necessary incident thereto for water power and supply purposes at a point between sections twenty, twenty-nine, and thirty-two in township one hundred and twenty-eight north, range twenty-nine west of the fifth principal meridian, and sections seventeen and twenty, in township thirty-nine, range thirty-two west of the fourth principal meridian, in Morrison County, Minnesota: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said the Pike Rapids Power Company, its successors or assigns, shall not deviate from such plans after

Provisos. Secretary of War to approve plans, etc.

Changes.

such approval, either before or after the completion of said structures, unless the modifications of such plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, and over said dam without unreasonable delay or hinderance [*sic*] and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for the purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of said dam as he may deem advisable in the interests of navigation."

Sluiceway.

Lock.

SEC. 2. That section four of said Act above referred to be, and the same is hereby, amended so as to read as follows:

"SEC. 4. That the right to amend, alter, or repeal this Act is hereby expressly reserved, and the same shall become null and void unless the construction of the dam hereby authorized is commenced within one year from June first, nineteen hundred and seven, and completed within three years thereafter, and that except so far as may be otherwise provided in this Act, the provision of the Act of Congress entitled 'An Act to regulate the construction of dams over navigable waters,' approved on the twenty-first day of June, nineteen hundred and six, shall be applicable to the construction of the dam provided in this Act."

Time of construction. Vol. 34, p. 210, amended.

Vol. 34, p. 386.

Approved, March 2, 1907.

CHAP. 277.—An Act To extend the time for commencing and completing the construction of a dam authorized by the act entitled "An Act permitting the building of a dam across the Mississippi River in the county of Morrison, State of Minnesota," approved June fourth, nineteen hundred and six.

Mar. 4, 1911. Vol. 36, p. 1359.

[H. R. 32721.] [Public, No. 517.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for commencing and completing the construction of the dam, canal, and other structures authorized by the Act of Congress approved June fourth, nineteen hundred and six, and its amendatory Act approved March second, nineteen hundred and seven, to be built across the Mississippi River, in Morrison County, Minnesota, is hereby extended one year and three years,

Mississippi River. Time extended for dam across, in Morrison County, Minn., by Pike Rapids Power Co. Vol. 34, p. 210, 1220.

respectively, from July first, nineteen hundred and eleven: *Provided*, That except as may be otherwise provided in the aforesaid Acts, the construction, maintenance, and operation of the said structures therein authorized shall be subject to, and in accordance with, the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Amendment.

Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 4, 1911.

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(38)

Mar. 12, 1904.
Vol. 33, p. 66.
[H. R. 9308.]
[Public, No. 47.]

CHAP. 542.—An Act Permitting the building of a dam across the Mississippi River between the counties of Wright and Sherburne, in the State of Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Minnesota Power and Trolley Company (a Minnesota corporation), its successors or assigns, to construct and maintain across the Missisippi River a dam, canal, and works necessarily incident thereto, for water-power purposes, at any point between section seventeen or eighteen, in township one hundred and twenty-one north, of range twenty-three west, in Wright County, and section six, in township thirty-two north, of range twenty-six west, in Sherburne County, Minnesota: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of construction of the same: *And provided further*, That the said Minnesota Power and Trolley Company, its successors or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the

Mississippi River.
Minnesota Power & Trolley Co. may dam, in Minnesota (near Otsego).
Location.
Provisos.
Secretary of War to approve plans, etc.
Modification of plans.
Sluiceways for logs, etc.
Aids to navigation.

said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of such dam as he may deem advisable in the interests of navigation: *And provided further*, That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts, as now provided for that purpose in the State of Minnesota and in the courts of the United States; but nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers or to exempt said structures from the operation of same.

Changes.

Litigation.

Existing laws not modified.

SEC. 2. That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by said corporation, its successors or assigns.

Fishways.

SEC. 3. That the right to amend, alter, or repeal this Act is hereby expressly reserved; and the same shall become null and void unless the construction of the dam hereby authorized be commenced within one year after the passage of this Act and completed within three years thereafter.

Amendment.

Time of construction.

Approved, March 12, 1904.

CHAP. 1128.—An Act Extending the time for the construction of the dam across the Mississippi River authorized by the Act of Congress approved March twelfth, nineteen hundred and four.

Mar. 22, 1906.
Vol. 34, p. 84.

[H. R. 15649.]
[Public, No. 63.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That subject to all the other provisions contained in the Act of Congress entitled "An Act permitting the building of a dam across the Mississippi River between the counties of Wright and Sherburne, in the State of Minnesota," approved March twelfth, nineteen hundred and four, the time limitations for the construction and completion of the dam authorized by said Act are hereby extended until December thirty-first, nineteen hundred and eight.

Mississippi River, Minn.
Time extended for constructing dam (near Otsego) by Minnesota Power and Trolley Co.
Vol. 33, p. 67, amended.

Approved, March 22, 1906.

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(39)

Act of April 19, 1864 (Stats. L., vol. 13, p. 50), relates exclusively to the establishment of an arsenal at Rock Island, Ill., and makes no specific mention of water power,

and is therefore, not included in this compilation, it being cited here simply because of reference being made to it by subsequent laws concerning water power.

For history of operations by Ordnance Department concerning the development of this water power see "A History of the Rock Island Arsenal," etc., 1877, published by the Ordnance Department, United States Army.

Act of June 27, 1866 (Stats. L., vol. 14, pp. 75 and 76), appropriates $100,000 " to secure water power at the head of Rock Island." [See next to last paragraph of Section 4.]

No. 54. Joint Resolution to enable the Secretary of War to carry out an agreement in relation to water power for the arsenal at Rock Island.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and empowered to carry into effect the recommendations of the commissioners appointed under the acts of April nineteen, eighteen hundred and sixty-four, and June twenty-seven, eighteen hundred and sixty-six, relative to the Moline Water [Power] Company and the water power at Rock Island, Illinois, as contained in the report of said commissioners, and to make application for that purpose of the money heretofore appropriated for securing water power at the head of Rock Island.

Approved, March 2, 1867. [Stats. L., vol. 14, p. 573.]

No. 8. Joint resolution to appoint a commission to examine into the matter of contracts made by and between the United States and the Moline Water Power Company as to the water power at Moline, Illinois, and to report to Congress as to same.

Whereas the Moline Water Power Company, of Moline in the State of Illinois, complains that certain contracts made with said Company by the United States, through the Secretary of War, acting under the authority of Congress have not been carried out in good faith in developing and maintaining the water power at said town of Moline as required by said contracts, and that by reason of such failure said Company has sustained and is sustaining large damages, therefore,

Resolved, by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and required to appoint a commission to consist of three competent civil engineers, one of whom shall be the Chief of Engineers of the United States Army, whose duty it shall be to examine into the subject-matter of said contracts, made by and between the United States, as aforesaid, and the said Water Power Company, as to said water power, and the development and maintenance of the same, and to report to the Congress of the United

States at its next session, what if anything is necessary to be done by the United States to carry out in good faith said contracts, and to relieve said Water Power Company from its alleged grievances. Said report to be submitted through the Secretary of War, to the Congress of the United States at the commencement of its next session; and to be directed to the Speaker of the House of Representatives.

Approved, March 3, 1877. [Stats. L., vol. 19, p. 410.]

[Extract from sundry civil act approved March 3, 1879. Stats. L., vol. 20, p. 387.]

That the Secretary of War is hereby authorized and empowered to lease the water power, at Moline, or such portion as may be agreed upon, to the Moline Water Power Company upon such terms and conditions and for such term of years as may be agreed upon, if the same can be done consistently with the interests of the Government of the United States. Said lease to be made upon the condition that the said Moline Water Power Company shall go on and complete the development of the water power and maintain it at its own cost and expense.

[Extract from joint resolution approved June 20, 1879. Stats. L., vol. 21, p. 51.]

That the following paragraph in said sundry civil Act approved March 3, 1879, namely: "That the Secretary of War is hereby authorized and empowered to lease the water power at Moline, or such portion as may be agreed upon, to the Moline Water Power Company, upon such terms and conditions, and for such term of years, as may be agreed upon, if the same can be done consistently with the interests of the Government of the United States; said lease to be made upon the condition that the said Moline Water Power Company shall go on and complete the development of the water power and maintain it at its own cost and expense," be, and the same is hereby, repealed.

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(40)

CHAP. 860.—An Act Granting to the Davenport Water Power Company rights to construct and maintain a canal, power station, and appurtenant works in the Mississippi River, in Scott County, Iowa.

Apr. 5, 1904. Vol. 33, p. 158.

[S. 4142.] [Public, No. 82.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Davenport Water Power Company, a corporation created and organized under the laws of the State of Iowa, its successors and assigns, to erect, construct, operate, and maintain a canal along the north bank of the Mississippi River between Leclaire and Davenport, in Scott County,

Mississippi River.

Davenport Water Power Co. may construct a canal, etc., in Scott County, Iowa.

in the State of Iowa, to erect, construct, operate, and maintain a power station thereon, and to project, erect, construct, operate, and maintain such dams and other works as may be necessary within said limits for the development of water power and the generation, use, and transmission therefrom of electric energy and power at, in, and upon the Rock Island Rapids of the Mississippi River: *Provided*, That the said canal and appurtenant works shall be so designed, constructed, and operated as not to interfere in any way with the safe and convenient navigation of steamboats and other vessels or of rafts and barges over the Rock Island Rapids, at any stage of water; and the expense of any reconstruction or extension of or addition to existing works for the improvement of navigation on the said Rock Island Rapids, which may be found necessary, in the opinion of the Secretary of War, on account of the construction, maintenance, or operation of the said canal and appurtenant works, shall be borne by the said company, its successors, or assigns, under conditions to be prescribed by the Secretary of War: *And provided further*, That detailed plans for the construction and operation of the said canal and appurtenant works shall be submitted to and approved by the Secretary of War before the commencement of the construction of any portion of the said works; and that after the approval of the said plans no deviation therefrom shall be made without the prior approval by the Secretary of War of the said deviation: *And provided further*, That the said works and appurtenances shall be so designed, constructed, and operated as not to overflow or otherwise damage the lands and other property of the United States at Rock Island Arsenal, or injure or diminish the water power of the United States at the said arsenal, or the water power of any person, firm, or corporation having hydraulic works already constructed: *And provided further*, That before entering upon the construction of the said works, compensation shall be made to any person, firm, or corporation whose lands or other property may be taken, overflowed, or otherwise damaged by the construction, maintenance, and operation of the said works, in accordance with the laws of the State where such lands or other property may be situate.

Dams.

Provisos.
Unobstructed navigation.

Secretary of War to approve plans, etc.

Protection to Rock Island Arsenal, etc.

Payment of damages.

Protection to navigation.

SEC. 2. That the withdrawal of water from the Mississippi River and the discharge of water into the said river, for the purpose of operating the said canal and appurtenant works, shall be under the direction and control of the Secretary of War, and shall at no time be such as to impede or interfere with the safe and convenient navigation of the said river by means of steamboats or other vessels, or by rafts and barges, or to injure or diminish the water power of the United States at Rock Island Arsenal, or the water power of any person, firm, or cor-

poration having hydraulic works already constructed: *Provided*, That if any litigation arises from the construction, operation, or maintenance of the said works, or from the obstruction of any part of the Mississippi River by the said works or any portion thereof, cases may be tried in the proper courts as now provided for that purpose in the States of Illinois and Iowa, and the courts of the United States: *And provided further*, That suitable fishways shall be constructed and maintained by the said company its successors and assigns, at such of the dams and in such manner as may be required from time to time by the United States Fish Commission.

Provisos. Litigation.

Fishways.

SEC. 3. That this Act shall be null and void if actual construction of the works herein authorized be not commenced within three years and completed within six years from the date hereof.

Time of construction.

SEC. 4. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, April 5, 1904.

CHAP. 461.—An Act To amend an Act granting to the Davenport Water Power Company rights to construct and maintain a canal, power station, and appurtenant works in the Mississippi River in Scott County, Iowa.

Feb. 5, 1907. Vol. 34, p. 876.

[H. R. 21677.] [Public, No. 56.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act granting to the Davenport Water Power Company rights to construct and maintain a canal, power station, and appurtenant works in the Mississippi River in Scott County, Iowa, approved April fifth, nineteen hundred and four, be, and it is hereby, amended as follows: In section three of said Act strike out the word "three" and insert the word "six" in lieu thereof; also strike out the word "six" and insert the word "nine" in lieu thereof.

Mississippi River, Iowa. Time extended to construct canal by Davenport Water Power Co. between Davenport and Le Claire.

Vol. 33, p. 159, amended.

Approved, February 5, 1907.

(41)

CHAP. 231.—An Act Granting the consent of Congress to the Saint Cloud Water Power and Mill Company to construct a dam across the Mississippi River at Saint Cloud, Minnesota.

July 5, 1884. Vol. 23, p. 154.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Saint Cloud Water Power and Mill Company to construct across the Mississippi River, at some point within the incorporated limits of the city of Saint Cloud, a dam, canal, and works necessarily incident thereto, for water-power and other purposes, and in connection there-

Construction of dam, etc., across Mississippi River, St. Cloud, Minn., authorized.

Wagon and foot bridge.

Proviso. Not to interfere with dam and mill at Sauk Rapids.

with a wagon and foot-bridge for public travel: *Provided*, That said dam shall be so constructed as not to interfere with the existing dam and mill at Sauk Rapids, and so that the Government of the United States can at any time construct in connection therewith a suitable lock for navigation purposes: *Provided also*, That the Government of the United States may at any time take possession of said dam, and control the same for purposes of navigation, by paying said company the actual cost of the same, but shall not do so to the destruction of the water-power created by said dam: *Provided further*, That the works be constructed so as to provide for the free passage of saw-logs and rafts, and, when necessary, to permit the passage of boats; and, further, that such changes or modifications in the works as the Secretary of War may from time to time deem necessary in the interest of navigation shall be made, at the expense of the water-power company: *Provided further*, That in case of any litigation arising from the obstruction of the channel by the dam, canal, or bridge, the cause may be tried in the district court of the United States in which the works are situated.

Proviso. Rights of Government of United States reserved.

Proviso. Free passage of saw logs, rafts, etc.

Proviso.

SEC. 2. That the right to amend, alter, or repeal this act is hereby expressly reserved.

Approved, July 5, 1884.

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(42)

Feb. 26, 1904. Vol. 33, p. 52.

[S. 2818.] [Public, No. 28.]

CHAP. 167.—An Act Permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota.

Mississippi River. Sauk Rapids Water Power Co. may dam at Sauk Rapids, Minn.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Sauk Rapids Water Power Company, a corporation organized under the laws of the State of Minnesota, its successors and assigns, to build a dam across the Mississippi River at or near the Sauk Rapids, so called, in said river, and at or near the village of Sauk Rapids, Benton County, Minnesota, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said Sauk Rapids Water Power Company, its successors or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have previously been submitted to and received the ap-

Provisos. Secretary of War to approve plans, etc.

Modification of plans.

proval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of such dam as he may deem advisable in the interests of navigation: *And provided further*, That suitable fishways, to be approved by the United States Fish Commission, shall be constructed and maintained at said dam by the Sauk Rapids Water Power Company, its successors or assigns.

Sluiceway for logs, etc.

Aids to navigation.

Changes.

Fishways.

SEC. 2. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts, as now provided for that purpose in the State of Minnesota, and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said structures from the operation of same.

Litigation.

Proviso.

Existing laws not modified.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within three years and be completed within six years from the time of the passage of this Act.

Time of construction.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 26, 1904.

CHAP. 2505.—An Act To amend an Act entitled "An Act permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota," approved February twenty-sixth, nineteen hundred and four.

Mar. 2, 1907. Vol. 34, p. 1058.

[S. 8400.] [Public, No. 164.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota," approved February twenty-sixth, nineteen hundred and four, be, and the same is hereby, amended so as to read as follows:

Mississippi River. Dam at Sauk Rapids, Minnesota.

Vol. 33, p. 53, amended.

"SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within three years

Time extended for construction.

and six months and be completed within six years from the time of the passage of this Act."

Approved, March 2, 1907.

Feb. 13, 1911. Vol. 36, p. 902.

[S. 6693.] [Public, No. 852.]

CHAP. 48.—An Act To amend an act entitled "An act permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota," approved February twenty-sixth, nineteen hundred and four.

Mississippi River. Dam across at Sauk Rapids, Minn. Vol. 33, p. 58, amended. *Post*, p. 3072.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota," approved February twenty-sixth, nineteen hundred and four, be, and the same is hereby, amended so as to read as follows:

Time extended for construction. Vol. 34, p. 1058.

"SEC. 3. That this Act shall be null and void unless the construction of the dam herein authorized be commenced on or before the first day of July, anno Domini nineteen hundred and ten, and completed within two years from that date."

Approved, February 13, 1911.

Feb. 24, 1911. Vol. 36, p. 931.

[S. 10757.] [Public, No. 420.]

CHAP. 158.—An Act To amend an act entitled "An act permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota," approved February twenty-sixth, nineteen hundred and four.

Mississippi River. Time extended for damming at Sauk Rapids, Minn. Vol. 33, p. 58, amended.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across the Mississippi River at or near the village of Sauk Rapids, Benton County, Minnesota," approved February twenty-sixth, nineteen hundred and four, be, and the same is hereby, amended so as to read as follows:

Time of construction. Vol. 34, p. 1058. *Ante*, p. 3057.

"SEC. 3. That this Act shall be null and void and all rights acquired under the same forfeited unless the construction of the dam herein authorized be commenced on or before the first day of July, anno Domini nineteen hundred and eleven, and such construction continued with and the dam completed within two years from the date last mentioned."

Approved, February 24, 1911.

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(43)

CHAP. 591.—An Act Permitting the building of a dam across the Mississippi River between the village of Sauk Rapids, Benton County, Minnesota, and the city of Saint Cloud, Stearns County, Minnesota.

Feb. 20, 1905. Vol. 33, p. 723.

[S. 5972.] [Public, No. 83.]

Mississippi River. Sauk Rapids Manufacturing Company may dam, at Sauk Rapids, Minn.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Sauk Rapids Manufacturing Company, a corporation

organized under the laws of the State of Minnesota, its successors or assigns, to build a dam across the Mississippi River at the Sauk Rapids, so called, in said river, and between the village of Sauk Rapids, in Benton County, Minnesota, and the city of Saint Cloud, or an addition thereof, in Stearns County, Minnesota, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization thereof: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the construction of the same: *And provided further*, That the said Sauk Rapids Manufacturing Company, its successors or assigns, shall not deviate materially from said plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have been submitted previously to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That said dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control said dam so far as shall be necessary for purposes of navigation, but shall not destroy or reduce the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of said dam as he may deem advisable in the interests of navigation: *And provided further*, That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by said company, its successors or assigns.

Proviso. Secretary of War to approve plans, etc.

Modification of plans.

Sluiceway.

Aids to navigation.

Changes.

Fishways.

SEC. 2. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, such cases may be tried in the proper courts, as now provided for that purpose in the State of Minnesota and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said structures from the operation of the same.

Litigation.

Proviso. Existing laws not affected.

SEC. 3. That this Act shall be null and void unless the said dam herein authorized be commenced within one year and be completed within three years from the time of the passage of this Act.

Time of construction.

Amendment. SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, February 20, 1905.

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(44)

June 28, 1906. Vol. 34. p. 537. [H. R. 19481.] [Public No. 315.]

CHAP. 3566.—An Act Permitting the building of a dam across the Mississippi River between the counties of Stearns and Sherburne, in the State of Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to The Saint Cloud Electric Power Company, a Minnesota corporation, its successors or assigns, to construct and maintain across the Mississippi River a dam, canal, and works necessarily incident thereto for water power and supply purposes, and a lock for navigation purposes, which lock shall be operated and kept in repair, as may be required by the Secretary of War, by the said company at its own expense, at any point between section seven, township one hundred and twenty-three, range twenty-seven, in the county of Stearns and State of Minnesota, and section twenty-five, township thirty-five, range thirty-one, and sections thirty and thirty-one, in township thirty-five, range thirty west, in Sherburne County, Minnesota: *Provided*, That the plans for the construction of such dam and appurtenant works including a lock shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said The Saint Cloud Electric Power Company, its successors and assigns, shall not deviate from such plans after such approval, either before or after the completion of said structure, unless the modification of such plans shall have previously been submitted to and received the approval of the Chief of Engineers and the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway, so arranged so [*sic*] as to permit logs, timber, and lumber to pass around, through, and over said dam without unreasonable delay or hinderance [*sic*] and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith any further suitable lock for navigation purposes and may at any time without compensation control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require

Mississippi River. The St. Cloud Power Company may dam, in Minnesota (at Augusta).

Location.

Provisos. Approval of plans.

Changes.

Sluiceway.

Lock for navigation.

and enforce at the expense of the owners such modifications and changes in the construction of said dam as he may deem advisable in the interest of navigation: *And provided further*, That in consideration of the conveyance to the United States of America by said corporation, or its successors or assigns, of such suitable tract or tracts of land as may be approved or selected by the Chief of Engineers and the Secretary of War for lock or other purposes for such navigation as aforesaid, the right shall become and the same is hereby vested in the said The Saint Cloud Electric Power Company, its successors and assigns, to flow and inundate with water any islands in the Mississippi River situate above said proposed site and situated southerly of the municipal limits of Saint Cloud, Stearns County, Minnesota, which may belong to the United States of America and which have not been subjected to any entry under the homestead laws or other disposition at the time of the passage of this Act, such right of flowage to be enjoyed without any compensation to be paid to the United States of America, save and except the value of said lands so to be conveyed for lock or other purposes. Flowage rights.

SEC. 2. That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by said corporation, its successors or assigns. Fishways.

SEC. 3. That in case any litigation arises from the building of said dam or locks or from the obstruction of said river by said dam or appurtenant works cases may be tried in the proper courts as now provided for that purpose in the State of Minnesota or in the courts of the United States. Litigation.

SEC. 4. That the right to amend, alter, or repeal this Act is hereby expressly reserved, and the same shall become null and void unless the construction of the dam hereby authorized is commenced within one year after the passage of this Act and completed within three years thereafter. Amendment. Time of construction.

Approved, June 28, 1906.

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(45)

CHAP. 1487.—An Act Permitting the building of a dam across the Mississippi River between the counties of Stearns and Benton, in the State of Minnesota.

Apr. 28, 1904. Vol. 33, p. 295. [H. R. 14418.] [Public, No. 151.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Watab Rapids Power Company, a Minnesota corporation, its successors or assigns, to construct and maintain across the Mississippi River a dam and works necessary incident thereto for water power and supply purposes at

Mississippi River. Watab Rapids Power Co. may dam in Minnesota. Location.

any point not less than four hundred feet above the mouth of Watab River, between section twenty-one, in township one hundred and twenty-five north, range twenty-eight west, in Stearns County, and section nine, in township thirty-six north, range thirty-one west, in Benton County, Minnesota, which may be approved by the Chief of Engineers and the Secretary of War: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the aforesaid Watab Rapids Power Company, its successors or assigns, shall not deviate from such plans after such approval, neither before nor after the completion of said structures, unless the modification of said plans has been previously submitted to and received the approval of the Chief of Engineers and the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications and changes in the construction of said dam as he may deem advisable in the interests of navigation.

Provisos. Secretary of War to approve plans, etc.

Changes.

Sluiceways.

Lock.

Fishways. SEC. 2. That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by said corporation, its successors or assigns.

Litigation. SEC. 3. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the State of Minnesota, and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers or to exempt said structure from the operation of the same.

Provisos. Existing laws not affected.

Amendment. SEC. 4. That the right to amend, alter, or repeal this Act is hereby expressly reserved; and the Act shall become null and void unless the construction of the said dam is commenced within one year and completed within three years from the date of approval thereof.

Time of construction.

Approved, April 23, 1904.

(46)

CHAP. 12.—An Act To authorize the Great Northern Development Company to construct a dam across the Mississippi River from a point in Hennepin County to a point in Anoka County, Minnesota.

Jan. 12, 1911.
Vol. 36, p. 893.
[H. R. 25775.]
[Public, No. 333.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Great Northern Development Company, a corporation organized under the laws of the State of Maine, with special permit to do business in Minnesota, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Mississippi River at Coon Creek Rapids from a point in lot one, section two, township one hundred and nineteen, range twenty-one, Hennepin County, to a point in lot four, section twenty-seven, township thirty-one, range twenty-four, Anoka County, all in the State of Minnesota, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Mississippi River.
Great Northern Development Co. may dam, at Coon Creek Rapids, Minn.
Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, January 12, 1911.

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(47)

CHAP. 1136.—An Act To authorize the Missouri River Improvement Company, a Montana corporation, to construct a dam or dams across the Missouri River.

Feb. 20, 1907.
Vol. 34, p. 912.
[S. 7515.]
[Public, No. 98.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of the Government is hereby given to the Missouri River Improvement Company, a Montana corporation, its successors or assigns, to construct across the Missouri River at some point or points, to be approved by the Secretary of War, between sections twenty and twenty-one, township twenty-one north, range five east, and the north line of township twenty-four north, range eight east, Montana meridian, a dam and canals and appurtenances thereof for water power and other purposes, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, and in connection therewith a foot bridge or bridges for public use in accordance with the provisions of the Act entitled "An Act to regulate the construction of bridges over navigable waters," approved March twenty-third, nineteen hundred and six.

Missouri River, Mont.
Missouri River Improvement Company may dam (within 30 miles above Fort Benton).
Vol. 34, p. 386.
Footbridge.
Vol. 34, p. 84.

Amendment. SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 20, 1907.

[Somewhere within a distance of 30 miles above Fort Benton.]

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(48)

Apr. 28, 1904. Vol. 33, p. 570.

CHAP. 1821.—An Act To authorize the Ox Bow Power Company, of South Dakota, to construct a dam across the Missouri River.

[H. R. 11972.] [Public, No. 253.]

Missouri River, S. Dak. Ox Bow Power Co. may construct dam across. Location.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of the Government is hereby given to the Ox Bow Power Company, of South Dakota, its successors or assigns, to construct across the Missouri River, from lot three, in section twenty-six, township fourteen north, range three west of the Montana meridian, to the opposite bank of same river, to be approved by the Secretary of War, a dam, causeway, and the appurtenances thereof for water power and other purposes: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of construction, and when so approved no change shall be made in said plans without the prior approval of the Chief of Engineers and the Secretary of War: *Provided further*, That the said company shall construct and maintain in connection with said dam a suitable boom and log sluice; that suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained in said dam by said corporation, its successors or assigns; and shall obtain and convey to the United States, whenever requested to do so by the Secretary of War, clear title to such land as in his judgment may be required for constructions and approaches to said dam for transferring boats and freight around the same, and shall grant to the United States a free use of water power for operating such construction work; and to insure compliance with these conditions the said company shall execute and deliver to the Secretary of War a proper bond, in such amount as may be fixed by him: *And provided further*, That the said company shall be liable for any damage to private property resulting from the construction and operation of said dam and appurtenant works, either by overflow or otherwise, and proceedings to recover compensation for such damage may be instituted either in the State or Federal courts.

Provisos. Secretary of War to approve plans, etc. Booms, etc. Fishways. Conveyance of title to United States. Use of water power. Bond. Damages. Proceedings.

Time of construction. SEC. 2. That this Act shall be null and void unless the structures herein authorized shall be commenced within one year and completed within three years from the date of approval hereof.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

Approved, April 28, 1904.

CHAP. 2936.—An Act To amend an act entitled "An Act to authorize the Ox Bow Power Company of South Dakota to construct a dam across the Missouri River." Mar. 4, 1907. Vol. 34, p. 1415. [H. R. 25672.] [Public, No. 271.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section two of chapter eighteen hundred and twenty-one of the laws of eighteen hundred and ninety-four, approved April twenty-eighth, nineteen hundred and four, is hereby amended to read as follows: Missouri River, Mont. Time extended to Ox Bow Power Company to dam, at Ox Bow Bend.

"SEC. 2. That this Act shall be null and void unless the structures herein authorized shall be commenced within one year and completed within three years from the date of approval thereof." Time of construction. Vol. 33, p. 571, amended.

Approved, March 4, 1907, 11 a. m.

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(49)

[Extract from river and harbor act of June 3, 1896, relative to construction of dams across Missouri River above Stubbs Ferry, Mont.] June 3, 1896. Vol. 29, p. 231. [Public, No. 175.]

Improving the upper Missouri River between Stubbs' Ferry, in Montana, and the lower limits of Sioux City, Iowa. * * * *Provided*, That subject to such conditions as the Secretary of War may prescribe, any person, company, or corporation may construct a dam or dams across said river above Stubbs Ferry, with necessary canal and improvements to develop water power and for other useful purposes; * * * Missouri River. Stubbs Ferry, Mont., to Sioux City, Iowa. *Proviso.* Dams permitted.

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(50)

CHAP. 103.—An Act To authorize the Missouri River Power Company of Montana to construct a dam across the Missouri River. June 8, 1894. Vol. 28, p. 91. [Public, No. 85.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of the Government is hereby given to the Missouri River Power Company of Montana, its successors or assigns, to construct across the Missouri River, at some point at or near the southeast corner of Township Eleven north, of Range Two west, Montana meridian, to be approved by the Secretary of War, a dam, canal, and the appurtenances thereof, for water power and other purposes, and in connection therewith a foot-bridge or bridges for public use. Said dam shall be constructed under the supervision and control of the Secretary of War, and before the same shall be commenced the Missouri River Power Co. may dam Missouri River, Mont. Secretary of War to approve plans, etc.

plans and specifications shall be approved by the Secretary of War. The dam shall be furnished with a suitable boom and log sluice, and the company, or its successors and assigns, shall execute to the United States, with sureties approved by the Secretary of War, a bond in such sum as the Secretary may determine, conditioned to indemnify the United States against all claims for damages for overflow or otherwise caused by the construction of said dam.

Sluice, etc.

Government use, etc.

SEC. 2. That the United States shall be secured a free right of way for constructions and approaches to said dam for transferring boats and freight around the same, and a free use of water power for operating such construction works.

Amendment, etc.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved, and the rights and privileges hereby granted to said Missouri River Power Company shall expire at the end of fifty years from and after the approval of this Act.

Approved, June 8, 1894.

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(51)

Apr. 12, 1906. Vol. 34, p. 111.

[S. 4180.] [Public, No. 93.]

CHAP. 1617.—An Act To authorize the Capital City Improvement Company, of Helena, Montana, to construct a dam across the Missouri River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of the Government is hereby given to the Capital City Improvement Company, of Helena, Montana, its successors or assigns, to construct across the Missouri River, at some point between the south line of township twelve north, range two west, and the north line of township fourteen north, range three west, Montana meridian, to be determined by them and approved by the Secretary of War, a dam, canal, and appurtenances thereof, for water power, and other purposes, and in connection therewith a foot bridge, or bridges, for public use: *Provided,* That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of construction, and when so approved no change shall be made in said plans without the prior approval of the Chief of Engineers and the Secretary of War: *Provided further,* That whenever required to do so by the Secretary of War the said company shall construct and maintain in connection with said dam a suitable boom and log sluice; that suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained in said dam by said corporation, its successors and assigns; and shall obtain and convey to the United

Missouri River, Mont. Capital City Improvement Company, of Helena, may dam (in vicinity of Buck Rapids).

Canal, foot-bridges, etc.

Provisos. Secretary of War to approve plans, etc.

Sluiceway. Boom, etc.

States, whenever requested to do so by the Secretary of War, clear title to such land as in his judgment may be required for constructions and approaches to said dam for transferring boats and freight around the same, and shall grant to the United States a free use of water power for operating such construction work; and to insure compliance with these conditions the said company shall execute and deliver to the Secretary of War a proper bond in such amount as may be fixed by him: *And provided further*, That the said company shall be liable for any damage to private property resulting from the construction and operation of said dam and appurtenant works, either by overflow or otherwise, and proceedings to recover compensation for such damage may be instituted either in the State or Federal courts.

Transfer of freight, etc.

Bond.

Damages.

SEC. 2. That this Act shall be null and void unless the structures herein authorized shall be commenced within one year and completed within three years from the date of approval hereof.

Time of construction.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, April 12, 1906.

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(52)

CHAP. 156.—An Act To authorize the Rainy River Improvement Company to construct a dam across the outlet of Namakan Lake at Kettle Falls, in Saint Louis County, Minnesota.

Feb. 24, 1911.
Vol. 36, p. 931.
[S. 10596.]
[Public, No. 418.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Rainy River Improvement Company, a corporation organized under the laws of the State of Minnesota, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the outlet of Lake Namakan at Kettle Falls, in Saint Louis County, Minnesota, at a point suitable to the interests of navigation, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Namakan Lake.
Rainy River Improvement Co. may dam at Kettle Falls, Minn.

Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 24, 1911.

(53)

June 4, 1900. Vol. 31, p. 264.

[Public, No. 142.]

CHAP. 620.—An Act Permitting building a dam across New River.

F. H. Fries et al. may dam New River, Va.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to F. H. Fries and W. C. Ruffin, of the State of North Carolina, their successors and assigns, to erect, construct, and maintain across New River, in Grayson County, Virginia, at any point within two miles of the mouth of Stevens Creek, a dam and all other works necessarily incident thereto for water-power purposes: *Provided*, That the said F. H. Fries and W. C. Ruffin, their successors and assigns, shall make, at their own expense, such change and modification of the said dam as the Secretary of War may from time to time direct in the interests of the navigation of said river: *Provided further*, That ladders suitable for the passage of fish over the said dam shall be constructed and maintained by the said parties, their successors and assigns, as may from time to time be required by the United States Fish Commissioner: *Provided further*, That in case any litigation arises from the obstruction of the channel by the said dam, or works appurtenant thereto, that the same may be tried in the courts of the United States having proper jurisdiction.

Provisos. —changes. Passage of fish. Litigation.

Commencement and completion.

SEC. 2. That this Act shall become null and void unless the dam herein authorized shall be commenced within two years and completed within five years of the date hereof.

Amendment.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 4, 1900.

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(54)

Feb. 18, 1911. Vol. 36, p. 921.

[H. R. 31922.]
[Public, No. 395.]

CHAP. 120.—An Act To authorize the Virginia Iron, Coal and Coke Company to build a dam across the New River near Foster Falls, Wythe County, Virginia.

New River. Virginia Iron, Coal & Coke Co. may dam, near Foster Falls, Va.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Virginia Iron, Coal and Coke Company, a corporation organized under the laws of the State of Virginia, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the New River, at a point suitable to the interests of navigation, at a point near Foster Falls, Wythe County, in the State of Virginia, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams

Vol. 34, p. 386.

across navigable waters,' approved June twenty-first, nineteen hundred and six."

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

Approved, February 18, 1911.

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(55)

CHAP. 123.—An Act Authorizing the Ivanhoe Furnace Corporation, of Ivanhoe, Wythe County, Virginia, to erect a dam across New River.

Feb. 18, 1911. Vol. 36, p. 922.

[H. R. 31931.] [Public, No. 398.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Ivanhoe Furnace Corporation, of Ivanhoe, Wythe County, Virginia, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across New River, at a point suitable to the interests of navigation, at Ivanhoe, Wythe County, Virginia, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

New River. Ivanhoe Furnace Corporation may dam, at Ivanhoe, Va.

Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

Approved, February 18, 1911.

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(56)

CHAP. 3340.—An Act To grant to Charles H. Cornell, his assigns and successors, the right to abut a dam across the Niobrara River on the Fort Niobrara Military Reservation, Nebraska, and to construct and operate a trolley or electric railway line and telegraph and telephone lines across said reservation.

June 18, 1906. Vol. 34, p. 297.

[H. R. 17982.] [Public, No. 239.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Charles H. Cornell, his assigns, assignees, successors, and grantees, be, and are hereby, privileged, authorized, and granted the authority and right to construct, maintain, and use for power purposes a dam across the Niobrara River on parts of sections twenty-two and twenty-seven, township thirty-four north, range twenty-seven west of the sixth principal meridian, in the State of Nebraska, and to abut said dam on the east bank of said Niobrara River upon land which is a part of the Fort Niobrara Military Reservation, the property of the United States; and said dam may be of sufficient height and strength to support a body of water affording or fur-

Niobrara River. Charles H. Cornell may dam, etc., on Fort Niobrara Military Reservation, Nebr.

nishing as much as fifty feet effective head for power purposes, with the privilege of backing water upon or overflowing such part of the Fort Niobrara Military Reservation as may reasonably result from the proper construction, maintenance, and use of said dam, and that any damages caused thereby may be assessed by the Secretary of War and paid to the United States before any construction hereby provided for shall be commenced. * * * *Provided*, That the grants and privileges above specified as to such dam, water power * * * aforesaid shall become void unless the construction of said dam be commenced within two years from the approval of this Act and completed and put into operation within five years from the approval of this Act; * * * *Provided*, That a map of said proposed dam, storage reservoir * * * shall be filed with the honorable Secretary of War, and the location thereof shall by him be approved before any of these privileges herein aforesaid shall become effective: *Provided further*, That the privileges herein granted may at any time be rescinded or suspended by order of the Secretary of War; * * *

Overflow etc.

Damages.

Provisos. Time for completion.

Secretary of War to approve plans, etc.

Approved, June 18, 1906.

Feb. 18, 1911. Vol. 36, p. 920.

[H. R. 31662.] [Public, No. 398.]

CHAP. 118.—An Act Granting five years' extension of time to Charles H. Cornell, his assigns, assignees, successors, and grantees, in which to construct a dam across the Niobrara River, on the Fort Niobrara Military Reservation, and to construct electric light and power wires and telephone line and trolley or electric railway, with telegraph and telephone lines, across said reservation.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time given Charles H. Cornell, his assigns, assignees, successors, and grantees, by an Act of Congress entitled "An Act to grant to Charles H. Cornell, his assigns and successors, the right to abut a dam across the Niobrara River on the Fort Niobrara Military Reservation, Nebraska, and to construct and operate a trolley or electric railway line and telegraph and telephone lines across said reservation," approved June eighteen, nineteen hundred and six, in which to construct and to put into operation such dam, and to construct and suspend wires across the said Fort Niobrara Military Reservation for the purpose of transmitting electric light and power, and to complete the construction of telegraph wires across said military reservation; also, the time in which to complete the construction and commence the operation of the trolley or electric railway, with telegraph and telephone lines, over said Fort Niobrara Military Reservation, be, and the same is hereby, extended for five years from the date of the approval of this act: *Provided*, That the privileges granted in said Act may be revoked by order of the Secretary of War, in the event of which, on the further order of the Secretary of War so to do, any or all of the

Niobrara River. Time extended for damming, etc., on Fort Niobrara Military Reservation, Nebr. Vol. 34, p. 297, amended.

Right of way.

Provisos. Revocation of privileges.

constructions of any kind, improvement, fixtures, or appurtenances, shall be removed by the owner of the same at his or its own expense and cost, and without any claim of any kind from the United States.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved. **Amendment.**

Approved, February 18, 1911.

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(57)

CHAP. 11.—An Act Permitting the building of a dam across the Osage River at the city of Warsaw, Benton County, Missouri. **Jan. 14, 1901. Vol. 31, p. 729. [Public, No. 7.]**

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the city of Warsaw, being a city incorporated and organized under the laws of the State of Missouri, its successors or assigns, to construct, erect, and maintain a dam across the Osage River, in Benton County, in the State of Missouri, at said city of Warsaw, and all work necessarily incident thereto: *Provided*, That the said city of Warsaw, its successors or assigns, shall make such change and modification in the works as the Secretary of War may from time to time deem necessary in the interest of navigation, at its own cost and expense: *Provided further*, That in case any litigation arises from the building of said dam, the maintaining of the same, or from the obstruction of the said river by said dam or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the State of Missouri and the courts of the United States. **Warsaw, Mo., may dam Osage River.** ***Provisos.*** **Changes in construction.** **Litigation.**

SEC. 2. That the right to amend, alter, or repeal this Act is hereby expressly reserved: *And provided further*, That suitable fishways shall be constructed and maintained at said dam by said city, its successors and assigns. as may be required from time to time by the United States Fish Commissioner. **Amendment.** ***Proviso.*** **Fishways.**

SEC. 3. That this Act shall be null and void unless the dam herein authorized shall be completed within three years of the date hereof: *And provided further*, That such dam shall be constructed in such manner as not to injure or diminish the water power of any person or company having a dam or hydraulic works constructed: *And provided further*, That before the construction of said dam compensation shall be made to any person or company whose lands may be taken or overflowed in the construction or maintenance of such dam, in accordance with the laws of the State of Missouri. **Completion.** ***Provisos.*** **Hydraulic works not to be impaired.** **Damages.**

Approved, January 14, 1901.

(58)

Feb. 23, 1906. Vol. 34, p. 18. [H. R. 7085.] [Public, No. 20.]

CHAP. 501.—An Act Authorizing the Pea River Power Company to erect a dam in Coffee County, Alabama.

Pea River, Ala. Pea River Power Company may dam.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Pea River Power Company, a corporation, be, and is hereby, authorized to erect, build, have, and maintain a steel and concrete dam, or dam of other material, on Pea River, at a point four miles below, or about four miles below, the town of Elba, in Coffee County, State of Alabama: *Provided*, That the plans of said dam shall be submitted to and be approved by the Chief of Engineers and the Secretary of War before construction is commenced; and the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications in the construction of said dam as he may deem advisable in the interests of navigation: *Provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges; and suitable fishways, to be approved by the United States Fish Commission, shall be constructed and maintained on said dam.

Location. *Provisos.* Secretary of War to approve plans, etc. Changes. Sluiceways. Fishways.

Time of construction.

SEC. 2. That this Act shall be null and void unless the dam herein authorized is commenced within one year and completed within three years from the date hereof.

Amendment.

SEC. 3. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, February 23, 1906.

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(59)

June 1, 1906. Vol. 34, p. 205. [S. 6088.] [Public, No. 187.]

CHAP. 2568.—An Act Authorizing the construction of a dam across the Pend d'Oreille River, in the State of Washington, by the Pend d'Oreille Development Company, for the development of water power, electrical power, and for other purposes.

Pend d'Oreille River. Pend d'Oreille Development Company may dam, at Big Falls, Wash.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to, and it shall be lawful for, the Pend d'Oreille Development Company, a corporation duly incorporated under the laws of the State of Washington, its successors or assigns, to construct and maintain a dam across the Pend d'Oreille River at a point at or about the Big Falls (sometimes known as Metaline Falls) on the Pend d'Oreille River, in the county of Stevens, State of Washington, such point to be selected by the Pend d'Oreille Development Company, its successors or assigns, at said falls, or

within one thousand feet above or below the same, for the purpose of erecting, operating, and maintaining a power station, and to maintain inlet and outlet races or canals, and to make such other improvements as may be necessary for the development of water power, electrical power, and the transmission of the same, subject always to the provisions and requirements of this Act and to such conditions and stipulations as may be imposed by the Chief of Engineers and the Secretary of War for the protection of navigation and the property and other interests of the United States: *Provided*, That such dam and works shall not be built or commenced until after the plans and specifications for their construction, together with such drawings of the proposed construction and such map of the proposed locations as may be required for a full understanding of the subject have been submitted to the Secretary of War for his approval, and until after he shall have approved such plan and specifications and the location of such dams and accessory works; when the plans for any dam to be constructed under the provisions of this Act have been approved by the Secretary of War it shall not be lawful to deviate from such plans, either before or after the completion of the structure, unless the modification of such plans has previously been submitted to and received the approval of the Secretary of War.

Proviso. Secretary of War to approve plans, etc.

Changes.

SEC. 2. That the Government of the United States reserves the right at any time that the improvement of the navigation of the Pend d'Oreille River demands it to construct, maintain, and operate, in connection with any dam or other works built under the provisions of this Act, suitable lock or locks or any other structures for navigation purposes, and at all times to control such dam or dams or other structures, and the level of the pool caused by such dam or dams, to such an extent as may be necessary to provide facilities for navigation; and whenever Congress shall authorize the construction of such lock or other structures, the Pend d'Oreille Development Company, its successors or assigns, owning and controlling such dam or other structures, shall convey to the United States, under such terms as Congress shall prescribe, titles to such lands as may be required for such lock and approaches, and in addition thereto shall grant to the United States free of cost the free use of water power for building and operating such constructions: *Provided*, That the Pend d'Oreille Development Company, its successors or assigns, building, maintaining, or operating any dam or other structures under the provisions of this Act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise, in a court of competent jurisdiction. The Pend d'Oreille Development Company, its successors or assigns, owning or operating any such dam, shall maintain at their own expense such lights and other signals thereon and such

Locks, etc.

Protection to navigation.

Conveyance of title to United States.

Free use of water power.

Proviso. Damages.

Lights, etc.

fishways and such ways for the free passage of saw logs as the Secretary of Commerce and Labor shall prescribe.

Time of completion. SEC. 3. That this Act shall be null and void unless the dam herein authorized shall be commenced within two years and completed within five years from the date of the approval hereof.

Amendment. SEC. 4. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 1, 1906.

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(60)

Feb. 25, 1907. Vol. 34, p. 931.

[H. R. 24760.] [Public, No. 119.]

CHAP. 1196.—An Act Authorizing the construction of a dam across the Pend d'Oreille River, in the State of Washington, by the Pend d'Oreille Development Company, for the development of water power, electrical power, and for other purposes.

Pend d'Oreille River, Wash. Pend d'Oreille Development Company may dam.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to, and it shall be lawful for, the Pend d'Oreille Development Company, a corporation duly incorporated under the laws of the State of Washington, its successors or assigns, to construct and maintain a dam across the Pend d'Oreille River at a point at or about where Pierwee Creek empties into the Pend d'Oreille River, near the international boundary line in the county of Stevens, State of Washington, at such point to be selected by the said Pend d'Oreille Development Company, its successors or assigns, at the mouth of said Pierwee Creek, or within one thousand feet above or below the same, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Location.

Vol. 34, p. 386.

Amendment. SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 25, 1907.

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(61)

May 4, 1898. Vol. 30, p. 398.

[Public, No. 80.]

CHAP. 238.—An Act Permitting the building of a dam across Rainy Lake River.

Koochiching Company may dam Rainy River, Minn.

Vol. 31, p. 167.

Vol. 32, p. 485.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Koochiching Company, its successors and assigns, to construct across the Rainy Lake River, at any part of the rapids in section twenty-seven, township seventy-one north, range twenty-four west of the fourth principal meridian, in the State of Minnesota, a dam, canal, and

works necessarily incident thereto, for water-power purposes. The said dam shall be so constructed that there can at any time be constructed in connection therewith a suitable lock for navigation purposes: *Provided*, That the Government of the United States may at any time take possession of said dam and appurtenant works and control the same for purposes of navigation by paying the said company the actual cost of the same, but shall not do so to the destruction of the water power created by said dam to any greater extent than may be necessary to provide proper facilities for navigation: *Provided further*, That the works shall be constructed so as to provide for the free passage of saw logs and fish. The said Koochiching Company, its successors and assigns, shall make such change and modification in the works as the Secretary of War may from time to time deem necessary in the interests of navigation, at its own cost and expense: *Provided further*, That in case any litigation arises from the obstruction of the channel by the dam, canal, or other works erected in connection therewith, the case may be tried in the proper court of the United States in the district in which the works are situated.

Koochiching Company, lock.

Provisos.

Government possession.

Passage of saw logs and fish.

Changes.

Litigation.

SEC. 2. That the right to amend, alter, or repeal this Act is hereby expressly reserved.

Amendment.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within one year and completed within three years from the date hereof.

Commencement and completion.

Vol. 31, p. 167.

Approved, May 4, 1898.

CHAP. 346.—An Act To amend an Act entitled "An Act permitting the building of a dam across Rainy Lake River."

May 4, 1900.

Vol. 31, p. 167.

[Public, No. 89.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across Rainy Lake River," approved May fourth, eighteen hundred and ninety-eight, and granting to the Koochiching Company, its successors and assigns, the consent of Congress to construct a dam across the Rainy Lake River, be, and the same is hereby, amended so as to read as follows:

Time extended to the Koochiching Co. to dam Rainy River, Minn.

Vol. 30, p. 398.

"That this Act shall be null and void unless the dam herein authorized shall be commenced within three years and completed within five years after the fourth day of May, eighteen hundred and ninety-eight."

Vol. 32, p. 485.

Approved, May 4, 1900.

CHAP. 1305.—An Act Relating to the construction of a dam across Rainy River.

June 28, 1902.

Vol. 32, p. 485.

[Public, No. 186.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for the construction of a dam across the Rainy River by the Koochiching Company, its successors and assigns, as provided by chapter two hundred

Rainy River, Minn.

Time extended to the Koochiching Company to dam.

Vol. 30, p. 898. Vol. 31, p. 167. and thirty-eight of volume thirty of the Statutes at Large and chapter three hundred and forty-six of volume thirty-one of the Statutes at Large, is hereby extended to May fourth, nineteen hundred and seven.

Terms. Vol. 30, p. 898. SEC. 2. That the Koochiching Company, its successors and assigns, is hereby authorized to construct and maintain said dam, subject to the terms of said chapter two hundred and thirty-eight of volume thirty of the Statutes at Large, upon the plans now on file with the Secretary of War, or any modification of said plans which the Secretary of War may approve; and the Koochiching Company, its successors and asigns, is hereby authorized to construct such dam at such height as will raise the waters of Rainy Lake to high-water mark: *Provided*, That said dam shall be furnished with such openings or gates or waste ways as will carry the waters of the river at flood stage without raising the water higher than it would rise in the natural condition of the stream: *And provided further*, That nothing in this Act contained shall be construed as relieving the Koochiching Company, its successors or assigns, from liability for any damage inflicted upon private property by reason of the raising of the waters of the lake as aforesaid.

Height of dam.

Provisos. Waste ways.

Damages.

Effect. SEC. 3. That this Act shall take effect and be in force from and after its passage.

Approved, June 28, 1902.

Feb. 25, 1905. Vol. 33, p. 814. [H. R. 17831.] [Public, No. 108.]

CHAP. 797.—An Act Relating to a dam across Rainy River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Rainy River Improvement Company, a corporation organized under the laws of the State of Minnesota for the improvement of the navigation of Rainy River and Rainy Lake, and its successors and assigns, upon filing with the Secretary of War proof satisfactory to him of its succession to the rights and privileges granted to the Koochiching Company by the following Acts of Congress, namely: Chapter two hundred and thirty-eight of volume thirty of the Statutes at Large, " An Act permitting the building of a dam across Rainy Lake River," approved May fourth, eighteen hundred and ninety-eight; chapter three hundred and forty-six of volume thirty-one of the Statutes at Large, " An Act to amend an Act entitled ' An Act permitting the building of a dam across Rainy Lake River,' " approved May fourth, nineteen hundred; chapter thirteen hundred and five, volume thirty-two, of the Statutes at Large, " An Act relating to the construction of a dam across Rainy River," approved June twenty-eighth, nineteen hundred and two, shall have the right, subject to the restrictions, conditions, and terms of said several Acts, to construct and maintain the dam provided for therein,

Rainy River, Minn. Rainy River Improvement Company to succeed to rights of former company.

Vol. 30, p. 898.

Vol. 31, p. 167.

Vol. 32, p. 485.

at such height at the Secretary of War may approve: *Provided*, That such dam shall be completed on or before July first, nineteen hundred and eight.

Proviso. Time of construction.

SEC. 2. That upon filing the proof of its succession to the rights of the Koochiching Company, and the approval thereof by the Secretary of War, that officer shall issue to the Rainy River Improvement Company a certificate of such approval.

Proof of succession.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 25, 1905.

CHAP. 194.—An Act Extending the time for the construction of a dam across Rainy River.

May 28, 1908. Vol. 35, p. 273. [H. R. 15444.] [Public, No. 138.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Rainy River Improvement Company, a corporation organized under the laws of the State of Minnesota, as the successor to the rights and privileges heretofore granted to the Koochiching Company under the following acts of Congress, namely: Chapter two hundred and thirty-eight of volume thirty, Statutes at Large, entitled "An Act permitting the building of a dam across Rainy River," approved May fourth, eighteen hundred and ninety-eight; and of chapter seven hundred and ninety-seven of volume thirty-three, Statutes at Large, entitled "An Act relating to a dam across Rainy River," approved February twenty-fifth, nineteen hundred and five, and of the various Acts and provisions therein recited amending said Act approved May fourth, eighteen hundred and ninety-eight, and further subject to the restrictions, conditions, and terms of all of said Acts, is hereby authorized to construct and maintain a dam across Rainy River, Minnesota, at the place designated in said Acts, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, so far as the same shall be applicable thereto: *Provided*, That said dam shall be completed on or before July, nineteen hundred and eleven.

Rainy River. Time extended for damming, by Rainy River Improvement Company.

Vol. 30, p. 398.

Vol. 33, p. 814.

Vol. 34, p. 386.

Time of completion.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

J. G. CANNON
Speaker of the House of Representatives.
CHARLES W. FAIRBANKS
Vice-President of the United States and President of the Senate.

IN THE HOUSE OF REPRESENTATIVES
May 12, 1908.

The President of the United States having returned to the House of Representatives, in which it originated, the bill (H. R. 15444) "An Act extending the time for

the construction of a dam across Rainy River," with his objections thereto the House proceeded in pursuance of the Constitution to reconsider the same; and

Resolved, That the said bill pass, two-thirds of the House of Representatives agreeing to pass the same.

Attest:

A McDOWELL *Clerk*.

IN THE SENATE OF THE UNITED STATES
May 23, 1908.

The Senate having proceeded, in pursuance of the Constitution, to reconsider the bill entitled "An Act extending the time for the construction of a dam across Rainy River," returned to the House of Representatives by the President of the United States, with his objections, and sent by the House of Representatives to the Senate, with the message of the President returning the bill:

Resolved, That the bill do pass, two-thirds of the Senate agreeing to pass the same.

Attest: CHARLES G. BENNETT
Secretary.
By H. M. ROSE
Asst. Secy.

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(62)

Mar. 16, 1906.
Vol. 34, p. 65.
[S. 4128.]
[Public, No. 49.]

CHAP. 953.—An Act Permitting the building of a dam across the Red Lake River at or near the junction of Black River with said Red Lake River in Red Lake County, Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to William J. Murphy, his successors and assigns, to build a dam across the Red Lake River at or near the junction of the Black River, so called, with said Red Lake River, in Red Lake County, Minnesota, for the development of water power, and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said William J. Murphy, his successors or assigns, shall not deviate from such plans after such approval, either before or after the completion of said structures, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to

Red Lake River, Minn.
Dam by William J. Murphy authorized.
Location.

Provisos.
Secretary of War to approve plans.

Modification of plans.

Sluiceway.

permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges: *And provided further*, That the dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time, without compensation, control the said dam so far as shall be necessary for purposes of navigation, but shall not destroy the water power developed by said dam and structures to any greater extent than may be necessary to provide proper facilities for navigation, and that the Secretary of War may at any time require and enforce at the expense of the owners such modifications and changes in the construction of such dam as he may deem advisable in the interests of navigation: *And provided further*, That suitable fishways, to be approved by the United States Fish Commission, shall be constructed and maintained at said dam by the said William J. Murphy, his successors or assigns.

Lock.

Changes.

Fishways.

SEC. 2. That in case any litigation arises from the building of said dam, or from the obstruction of said river by said dam or appurtenant works, cases may be tried in the proper courts, as now provided for that purpose in the State of Minnesota and in the courts of the United States: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said structures from the operation of same.

Litigation.

Proviso.
Existing laws not affected.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within one year and be completed within three years from the time of the passage of this Act.

Time of construction.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Amendment.

Approved, March 16, 1906.

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(63)

CHAP. 256.—An Act Permitting the building of a dam across the Rock River at Grand Detour, Illinois.

Feb. 16, 1906.
Vol. 34, p. 14.
[H. R. 8442.]
[Public, No. 16.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to Spencer B. Newberry and George A. Blackford, both of the city of Sandusky, Erie County, Ohio, and Charles H. Hughes, of Dixon, Lee County, Illinois, their heirs, administrators, successors, and assigns, to build, operate, and maintain a dam across Rock River near Grand Detour, Illinois, at any point within one mile distant from the center of section thirteen, township twenty-two north,

Rock River.
Dam, etc., at Grand Detour, Ill., authorized.

range nine east of the fourth principal meridian, in the State of Illinois, for the development of water power and such works and structures in connection therewith as may be necessary or convenient in the development of said power and in the utilization of the power thereby developed; and the said Spencer B. Newberry, George A. Blackford, and Charles H. Hughes, their heirs, administrators, successors, and assigns, are hereby authorized and empowered to draw and divert by canal, flume, or race from the pool formed by the construction of the above dam and works incident thereto, such supply of water as may be required for the full development and utilization of said water power and to conduct said water through the canal reservation in Grand Detour and discharge the same into said Rock River at or near the westerly end of said canal reservation, and also for that purpose to construct, operate, and maintain such structures and improvements as may be required: *Provided*, That the plans for the construction of the said dam, canal, and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of the same: *And provided further*, That the said Spencer B. Newberry, George A. Blackford, and Charles H. Hughes, their heirs, administrators, successors, and assigns, shall not deviate from such plans after such approval either before or after the completion of the structures therein described, unless the modification of said plans shall have been previously submitted to and received the approval of the Chief of Engineers and Secretary of War: *And provided further*, That suitable fishways shall be constructed and maintained by the grantees under the Act at their own expense, as may be required from time to time by the United States Fish Commission: *And provided further*, That the said dam shall be so constructed that the Government of the United States may at any time construct in connection therewith a suitable lock for navigation purposes, and may at any time control the said dam so far as shall be necessary for the purposes of navigation, but shall not destroy or impair the water power developed by said dam, canal, and appurtenant structures to a greater extent than shall be necessary to provide proper facilities for navigation, and other purposes of public interest.

Use of water supply.

Provisos. Secretary of War to approve plans, etc.

Changes.

Fishways.

Lock.

Litigation.

SEC. 2. That in case any litigation arises from the building, operation, and maintenance of said dam, canal, and appurtenant works, or from the obstruction of the river by the same, or any damages resulting to private property by overflow or otherwise, proceedings to adjust, determine, and to recover compensation for such damages shall be instituted either in the State or Federal courts.

Time of construction.

SEC. 3. That this Act shall be null and void unless the dam, canal, and appurtenant works herein authorized be

commenced within three years and completed within six years from the time of the passage of this Act.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, February 16, 1906.

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(64)

CHAP. 1438.—An Act Authorizing the construction of a dam across Rock River at Lyndon, Illinois. Mar. 3, 1905. Vol. 33, p. 1004.

[H. R. 15440.] [Public, No. 171.]

Rock River, Ill. Dam authorized across at Lyndon.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That permission be given to Edward A. Smith, Harvey S. Green, and John J. Hurlbert, of Morrison, Illinois, or their assigns, to erect a dam with an eight-foot head across Rock River at or near Lyndon, Whiteside County, Illinois, the south end of said dam to be located near the line between sections twenty-one and twenty-two in town twenty north of range five east of the fourth principal meridian, and the north end of said dam to intersect the bank of said river in section twenty-one in the same town, range, and meridian: *Provided*, That the plans for the construction of said dam shall be submitted to and approved by the Chief of Engineers and the Secretary of War, and until approved by them the construction of the dam shall not be commenced; and after such approval the plans shall not be changed, either before or after the completion of the structure, unless authorized by the Chief of Engineers and the Secretary of War, and the Secretary of War may at any time require and enforce at the expense of the owners of the structure such modifications and changes in said structure as he may deem advisable in the interest of navigation: *Provided further*, That the Secretary of War may at any time require the grantees under this Act to construct at their own expense in connection with said dam suitable locks, canals, sluiceways, or other structures, for the passage of boats and other water craft, the said structures to be built upon plans which he may approve; and the said grantees shall maintain and operate said locks, canals, and other structures at their own expense, and shall pass all water craft through the same without delay and without any charge whatever as long as said dam is maintained; and if said dam and other structures shall be abandoned by the said grantees at any time, all portions thereof shall be promptly removed by the grantees at their own expense.

Provisos. Secretary of War to approve plans, etc.

Locks, etc.

SEC. 2. That before entering upon the construction of the works herein authorized compensation shall be made to any person, firm, or corporation whose lands or other property may be taken, overflowed, or otherwise damaged by the construction, maintenance, and operations of the

Payment for damages.

said works in accordance with the laws of the State where such lands or other property may be situated, and if any litigation arises from the construction, operation, or maintenance of the said works, cases may be tried in the proper courts, as now provided for that purpose in the State of Illinois and the courts of the United States.

Litigation.

Fishways.

SEC. 3. That such suitable fishways shall be constructed and maintained by the grantees under this Act at their own expense as may be required from time to time by the United States Fish Commission.

Time of construction.

SEC. 4. That this Act shall be null and void if actual construction of the dam herein authorized be not commenced within two years and completed within four years from the date hereof.

Amendment.

SEC. 5. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 3, 1905.

Feb. 25, 1907.
Vol. 34, p. 933.
[H. R. 25234.]
[Public, No. 124.]

CHAP. 1201.—An Act Permitting the building of a dam across Rock River at Lyndon, Illinois.

Rock River.
Edward A. Smith et al. may dam, at Lyndon, Ill.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Edward A. Smith, Harvey S. Green, and John J. Hurlbert, of Morrison, Illinois, their heirs, administrators, executors, successors, and assigns, are hereby authorized to construct and maintain a dam across Rock River at or near Lyndon, Whiteside County, Illinois, the south end of said dam to be located near the line between sections twenty-one and twenty-two in township twenty north, range five east, fourth principal meridian, and the north end of said dam to intersect the bank of said river in section twenty-one in the same township, range, and meridian, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Vol. 34, p. 386.

Amendment.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, February 25, 1907.

Feb. 18, 1911.
Vol. 36, p. 920.
[H. R. 30571.]
[Public, No. 392.]

CHAP. 117.—An Act Permitting the building of a dam across Rock River at Lyndon, Illinois.

Rock River.
Edward A. Smith and Harvey S. Green may dam, at Lyndon, Ill.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Edward A. Smith and Harvey S. Green, of Morrison, Illinois, their heirs, administrators, executors, successors, and assigns, are hereby authorized to construct, maintain, and operate a dam across Rock River at a point suitable to the interests of navigation at or near Lyndon, Whiteside County, Illinois, the south end of said dam to be located near the line between sections twenty-one and twenty-two in township twenty north, range five east,

fourth principal meridian, and the north end of said dam to intersect the bank of said river in section twenty-one in the same township, range, and meridian, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six." Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

Approved, February 18, 1911.

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(65)

May 1, 1906.
Vol. 34, p. 155.
[H. R. 14508.]
[Public, No. 137.]

CHAP. 2072.—An Act Permitting the building of dams across the north and south branches of Rock River, adjacent to Vandruffs Island and Carrs Island, and across the cut-off between said islands, in Rock Island County, Illinois, in aid of navigation and for the development of water power.

Rock River, Ill.
Samuel S. Davis may dam, in Rock Island County.
Location.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to Samuel S. Davis, of the city of Rock Island, in the county of Rock Island and State of Illinois, his heirs, executors, administrators, and assigns, to build, operate, and maintain dams across the north and the south branches or channels of Rock River adjacent to Vandruffs Island and to Carrs Island, and across the cut-off between said islands, in said county of Rock Island, State of Illinois, in aid of navigation and for the development of water power, together with such works and structures in connection therewith as may be necessary or convenient in the development of said power and the utilization of the power thereby developed; said dams may be built at or near the sites of the dams formerly existing across said branches and said cut-off, or at any place or places between said sites and the dams now constructed at or near the head of said Carrs Island for the purposes of the Illinois and Mississippi Canal, and the said Samuel S. Davis, his heirs, executors, administrators, and assigns are hereby authorized and empowered to draw and divert by canal, flume, or race, or canals, flumes, and races, from the pool formed by the construction of said dams and works incident thereto, such supply of water as may be required for the full and complete development and utilization of said water power, and to discharge the same into said Rock River or some branch or channel thereof at or near the lower part of said Vandruffs Island, or at some place or places on or near the north shore of said river or of the north branch or channel thereof opposite to or below said Vandruffs Island; and also for that purpose to construct, Canal, etc.

operate, and maintain such structures and improvements as may be necessary or convenient: *Provided*, That such dams shall not be built or commenced until the plans and specifications for their construction, together with such drawings of the proposed construction and such map of the proposed locations as may be required for a full understanding of the subject, have been submitted to the Secretary of War for his approval, or until he shall have approved such plans and specifications and the location of such dams and accessory works; and when the plans for any dam to be constructed under the provisions of this Act have been approved by the Secretary of War it shall not be lawful to deviate from such plans, either before or after completion of the structure, unless the modification of such plans has previously been submitted to and received the approval of the Secretary of War: *Provided*, That in approving said plans and locations such conditions and stipulations may be imposed as the Secretary of War may deem necessary to protect the present and future interests of the United States, which may include the condition that said Samuel S. Davis, his heirs, executors, administrators, or assigns, shall construct, maintain, and operate, without expense to the United States, in connection with said dams and appurtenant works, a lock or locks, booms, sluices, or any other structures which the Secretary of War at any time may deem necessary in the interest of navigation, in accordance with such plans as he may approve, and also that whenever Congress shall authorize the construction of a lock or other structures for navigation purposes in connection with such dams, the person owning such dams shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States a free use of water power for building and operating such constructions: *And provided further*, That suitable fishways shall be constructed and maintained in said dams by said Samuel S. Davis, his heirs, executors, administrators, or assigns, at his or their own expense, as may be required from time to time by the Secretary of Commerce and Labor: *And provided further*, That said dams and other structures shall be so constructed as in the judgment of the Secretary of War not to interfere with the Illinois and Mississippi Canal and the operation thereof, and the Secretary of War shall at any time control said dams so far as shall be necessary for the purposes of said last above-mentioned canal, but shall not destroy or impair the water power developed by said dams, canals, and appurtenant structures to a greater extent than shall be necessary to provide proper facilities for the navigation of said Illinois and Mississippi Canal or other purposes affecting navigation; and the said Secretary of War may impose reasonable charges for the use of the flowage rights of the United States, if any, below the sites of the present Gov-

Provisos.
Secretary of War to approve plans, etc.

Locks, etc.

Fishways.

Illinois and Mississippi Canal.
Operation of not to be affected.

ernment dams at the head of said Carrs Island: *And provided further*, That the Secretary of War is hereby authorized, if in his judgment the interests of the United States will not be injured thereby, to permit the dam across the south branch of Rock River to be located and built on land belonging to the United States, under and subject to such terms and conditions as he may consider just and reasonable. Dam across South Branch of Rock River.

SEC. 2. That in case any litigation arises from the building, operation, and maintenance of said dams, canals, and appurtenant works, or from the obstruction of said river by the same, or any damages resulting to private property by overflow or otherwise, proceedings to adjust, determine, and recover compensation for such damages may be instituted in any court of competent jurisdiction. Litigation.

SEC. 3. That unless the actual construction of the dams herein authorized shall be commenced within one year and completed within three years after the passage of this Act, the rights and privileges herein granted, so far as they pertain to the construction of any dam or dams not then completed, shall cease and determine. Time of construction.

SEC. 4. That the right to alter, amend, and repeal this Act is hereby expressly reserved. Amendment.

Approved, May 1, 1906.

[Extract from the river and harbor act of March 3, 1909.] Mar. 3, 1909. Vol. 35, p. 819.

[H. R. 28243.] [Public, No. 317.]

SEC. 8. That section three of "An Act permitting the building of dams across the North and South branches of Rock River, adjacent to Vandruffs Island and Carrs Island, and across the cut-off between said islands, in Rock Island County, Illinois, in aid of navigation and for the development of water power," approved May first, nineteen hundred and six, be, and the same is hereby amended by extending the time for the completion of the dam across the south branch to May first, nineteen hundred and eleven: *Provided*, That the said dam shall, immediately upon its completion, become the property of the United States, and that the grantee under the said Act of May first, nineteen hundred and six, shall operate and maintain the other works authorized by the said Act in accordance with and subject to the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, so far as such provisions may be applicable. Rock River, Ill. Time extended for daming south branch. Vol. 34, p. 156, amended. *Provisos.* Transfer of dam to United States. Operation. Vol. 34, p. 386.

(66)

[Extract from river and harbor act approved March 2, 1907.] Mar. 2, 1907. Vol. 34, p. 1103.

[H. R. 24991.] [Public, No. 168.]

The Secretary of War is authorized to permit the Sterling Hydraulic Company, of Sterling, Illinois, to erect, own, and operate a power station in connection with the

Rock River, Ill. Dam authorized across, at Sterling. Provisos. Approval of location, etc. Navigation not to be obstructed. Condition.

dam built or to be built by the United States in Rock River at or near Sterling, Illinois, in connection with the construction of the Illinois and Mississippi Canal: *Provided*, That the location and plans of said power station shall be subject to the approval of the Secretary of War: *Provided further*, That the navigation of Rock River and of the Illinois and Mississippi Canal and the operation and maintenance of said dam shall be in no way obstructed thereby: *And provided further*, That prior to the issue of said permit the Sterling Hydraulic Company shall waive any and all claims that it may have against the United States by reason of the construction, operation, and maintenance of the Illinois and Mississippi Canal, except such claims as it may have for the abstraction from Rock River of more than three hundred cubic feet of water per second when the flow of Rock River immediately above is less than one thousand cubic feet of water per second.

(67)

Feb. 18, 1911. Vol. 36. p. 922. [H. R. 31926.] [Public, No. 397.]

CHAP. 122.—An Act Permitting the building of a dam across Rock River near Byron, Illinois.

Rock River. Byron Water Power Co. may dam, near Byron, Ill. Vol. 34, p. 386.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Byron Water Power Company, a corporation organized under the laws of the State of Illinois, with is principal office at Byron, Illinois, its successors and assigns, is hereby authorized to construct and maintain a dam across Rock River, at a point suitable to the interests of navigation, near the upper end of an island in said river at or near the north line of the south half of the southeast quarter of section twenty, township twenty-five north, range eleven east, of the fourth principal meridian, in Ogle County, Illinois, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

(68)

Feb. 7, 1903. Vol. 32, p. 802. [Public, No. 64.]

CHAP. 513.—An Act Permitting the building of a dam across the St. Croix River at or near the village of St. Croix Falls, Polk County, Wisconsin.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to

St. Croix Falls Wisconsin Improvement Company, a corporation organized under the laws of the State of Wisconsin, and to St. Croix Falls Minnesota Improvement Company, a corporation organized under the laws of the State of Minnesota, or either of them, their and each of their successors or assigns, to build a dam across the St. Croix River at or near the St. Croix Falls, so called, in said river, and all works incident thereto in the utilization of the power thereby developed: *Provided*, That the plans for the construction of said dam and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of such dam: *And provided further*, That said St. Croix Falls Wisconsin Improvement Company and said St. Croix Falls Minnesota Improvement Company, or either of them, their and each of their successors or assigns shall not deviate from such plans after such approval either before or after the completion of the structure, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *And provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through or over said dam, without unreasonable delay or hindrance, and without toll or charges; that the Government of the United States may, at any time, construct in connection therewith a suitable lock for navigation purposes, may at any time without compensation control the said dam for purposes of navigation, but shall not destroy the water power created by said dam to any greater extent than may be necessary to provide proper facilities for navigation; and that the Secretary of War may, at any time, require and enforce, at the expense of the owners, such modifications and changes in the construction of said dam and may make such regulations for the operation of said dam as he may deem advisable in the interests of navigation.

St. Croix River, Wis.
St. Croix Falls Wisconsin Improvement Co., et al., may dam at St. Croix Falls.
Provisos.
Plans to be approved by the Secretary of War.
Construction of sluiceway.
Aids to navigation.
Changes.

SEC. 2. That in case any litigation arises from the building of said dam or from the obstruction of said river by said dam or appurtenant works cases may be tried in the proper courts, as now provided for that purpose in the States of Wisconsin and Minnesota, and in the courts of the United States.

Litigation.

SEC. 3. That this Act shall be null and void unless the dam herein authorized be commenced within two years and completed within five years from the time of the passage of this Act.

Time of construction.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 7, 1903.

(69)

Apr. 5, 1906. Vol. 34, p. 102.

[H. R. 16671.]

[Public, No. 85.]

CHAP. 1368.—An Act Permitting the building of a dam across the Saint Joseph River near the village of Berrien Springs, Berrien County, Michigan.

St. Joseph River, Mich.

Berrien Springs Power and Electric Co. may dam. Location.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Berrien Springs Power and Electric Company, a corporation organized under the laws of the State of Michigan, its successors and assigns, to construct, erect, and maintain a dam across the Saint Joseph River, in Berrien County, in the State of Michigan, at any point within two miles south of the highway bridge at Berrien Springs, together with all necessary works appurtenant thereto: *Provided*, That the plans of said dam shall be submitted to and be approved by the Chief of Engineers and the Secretary of War before construction is commenced; and the Secretary of War may at any time require and enforce, at the expense of the owners, such modifications in the construction of said dam as he may deem advisable in the interest of navigation: *Provided further*, That there shall be placed and maintained in connection with said dam a sluiceway so arranged as to permit logs, timber, and lumber to pass around, through, or over said dam without unreasonable delay or hindrance and without toll or charges, and suitable gates, weirs, and sluices shall be provided in said dam and shall be so operated as to furnish at all times the flow of water necessary for the navigation of the Saint Joseph River below Berrien Springs; and suitable fishways, to be approved by the United States Fish Commission, shall be constructed and maintained on said dam.

Provisos. Secretary of War to approve plans, etc.

Sluiceway.

Fishways.

Damages.

SEC. 2. That before the construction of said dam shall be begun, the permission of the board of supervisors of Berrien County, Michigan, shall be obtained thereto, and compensation shall be made for all property taken or damages thereby occasioned according to the laws of the State of Michigan.

Time of construction.

SEC. 3. That this Act shall be null and void unless the dam herein authorized is commenced within one year and completed within three years from the date hereof.

Amendment.

SEC. 4. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, April 5, 1906.

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(70)

Mar. 2, 1907. Vol. 34, p. 1254.

[H. R. 25832.]

[Public, No. 288.]

CHAP. 2579.—An Act To authorize Herman L. Hartenstein to construct a dam across the Saint Joseph River, near the village of Mottville, Saint Joseph County, Michigan.

St. Joseph River, Mich.

Herman L. Hartenstein may dam, at Mottville.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Herman L. Hartenstein, a citizen of the State

of Michigan, his heirs and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Saint Joseph River, at any point up the stream within one mile from the highway bridge at the village of Mottville, Saint Joseph County, in the State of Michigan, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six. Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

Approved, March 2, 1907.

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(71)

Chap. 11.—An Act To authorize the city of Sturgis, Michigan, to construct a dam across the Saint Joseph River.

Jan. 12, 1912. Vol. 36, p. 893.

[H. R. 6867.] [Public, No. 332.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the city of Sturgis, a corporation organized under the laws of the State of Michigan, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Saint Joseph River, at or near its intersection with the section line between sections one and two, township six south, range eleven west, Saint Joseph County, in the State of Michigan, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

St. Joseph River, Sturgis, Mich., may dam.

Vol. 34, p. 386.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

Approved, January 12, 1911.

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(72)

[Extract from the river and harbor act of June 13, 1902.]

June 13, 1902. Vol. 32, p. 361.

[Public, No. 154.]

Subject to the express precedent conditions hereinafter mentioned, the Michigan Lake Superior Power Company, of Sault Sainte Marie, Michigan, its successors and assigns, after first obtaining consent of the Secretary of War and the Chief of Engineers and their approval of the said canal and remedial works proposed, is hereby authorized to divert water from the Saint Marys River into its water-power canal now being constructed at Sault Sainte Marie, Michigan, for water-power purposes

Water-power canal at Sault Sainte Marie, Mich.

Diversion of water into.

while and so long as such works and diversion of water from said river shall not injuriously affect navigation therein, nor impair or diminish the water levels or any natural increase thereof either in Lake Superior or in the United States ship canal and locks or the navigable channels, locks, or ship canals connected therewith, whether natural or artificial, now existing or which may hereafter be established or created by the United States for navigation purposes. And conditioned further, that said company shall establish, maintain and operate suitable and sufficient remedial and controlling works in the rapids of said river, to the approval of the Secretary of War and the Chief of Engineers; and said company shall maintain and operate said canal and works in accordance with any rules and regulations that may hereafter be recommended by any International Commission and that shall become operative. Whenever, in the judgment of the Secretary of War, the operation of said canal and remedial and controlling works, or either of them, either in themselves or in conjunction with any other canal or canals in the United States or Canada which now or hereafter may exist, is injuriously affecting water levels or the navigation of Lake Superior, the River Saint Marys or other channels, locks or ship canals connected therewith as hereinbefore provided, he shall impose upon said Company such rules and regulations for the operation of said canal and remedial works, as may, in his opinion, be necessary to prevent such injury. It shall become his duty, and he shall have the authority to enter upon the property of said company and to close said canal in whole or in part to the extent necessary to maintain water levels and to require said Company, at its own expense, to remove, add to or modify said works or any part thereof to the extent necessary to maintain water levels. Neither the Secretary of War nor the Chief of Engineers or any officer or other person acting under direction of them or either of them, shall be in any way liable by reason of anything done in the execution of this provision.

Protection to water into.

Secretary of War to prescribe regulations.

Maintenance of water levels.

Nonliability.

Remedies.

All remedies herein provided however, shall be cumulative and shall be without prejudice to any other remedies either of the United States or of individuals for failure of said Company to maintain said levels for navigation purposes as herein provided.

Riparian rights.

Right to amend, etc.

Nothing herein contained shall be held to affect any existing riparian or other rights of any person or corporation, or the existing remedies therefor, or any action at law or equity now pending. The right is hereby expressly reserved to Congress to alter, amend or repeal the provisions contained in this paragraph.

[Extract from river and harbor act of March 3, 1909.]

Mar. 3, 1909. Vol. 35, p. 821.

[H. R. 28243.] [Public, No. 317.]

SEC. 12. That part of the Act entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved June thirteenth, nineteen hundred and two, in section one, relating to the Michigan-Lake Superior Power Company, is hereby amended by adding the following:

Michigan-Lake Superior Power Company. Vol. 32, p. 361, amended.

Declaration of right of United States to flow of water, etc.

The right to the flow of water, and riparian, water power, and other rights, now or hereafter owned by the United States, in the Saint Marys River in Michigan shall be forever conserved for the benefit of the Government of the United States, primarily for the purposes of navigation and incidentally for the purpose of having the water power developed, either for the direct use of the United States, or by lease or other agreement, through the Secretary of War, who is hereby authorized to make such leases or agreements: *Provided*, That a just and reasonable compensation shall be paid for the use of all waters or water power now or hereafter owned in said Saint Marys River by the United States, whether utilized in said river or in any lateral canal, said compensation to be fixed by the Secretary of War: *Provided further*, That under no circumstances shall any rights be granted in said river which will interfere with the needs and uses of navigation, or which will limit the absolute control of said land and waters when desired for purposes of navigation by the United States, or for a longer period than thirty years, and the Secretary of War, in his discretion, may provide for readjustment of compensation at periods of ten years, nor shall any such rights be granted without just and adequate compensation. It is intended that any excess of water in the Saint Marys River at Sault Sainte Marie over and above the amount now or hereafter required for the uses of navigation shall be leased for power purposes by the Secretary of War upon such terms and conditions as shall be best calculated in his judgment to insure the development thereof. The Secretary of War may, as often as necessary, make such regulations as in his judgment are reasonable and just and best calculated to carry out the purposes of this section.

Leases authorized.

Provisos.

Compensation to be paid for use.

Limitation on all grants.

Only excess of water for navigation to be leased.

Regulations, etc.

SEC. 13. That for examinations, surveys, and contingencies, and for incidental repairs for rivers and harbors for which there may be no special appropriation, the sum of seven hundred thousand dollars is hereby appropriated, to be immediately available.

Appropriation for examinations, etc.

The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys to be made at the localities named in this section, as hereinafter set forth, and a sufficient sum to pay the cost thereof may be allotted from the amount appropriated in this section. In all cases a preliminary examination of the river, harbor, or other proposed improvement mentioned

Preliminary examinations to be made.

Report on advisability. shall first be made, and a report as to the advisability of its improvement shall be submitted, unless a survey or estimate is herein expressly directed. If upon such preliminary examination the proposed improvement is not deemed advisable, no further action shall be taken thereon without the further direction of Congress; but in case the report shall be favorable to such proposed improvement, or that a survey and estimate should be made to determine the advisability of improvement, the Secretary of War is hereby authorized, in his discretion, to cause surveys to be made, and the cost and advisability to be reported to Congress. Such examinations and surveys shall be reviewed by the Board of Engineers for Rivers and Harbors, as provided in section three of the river and harbor Act of March second, nineteen hundred and seven: *Provided*, That every report submitted to Congress in pursuance of this section, in addition to full information regarding the present and prospective commercial importance of the project covered by the report, and the benefit to commerce likely to result from any proposed plan of improvement, shall contain also such data as it may be practicable to secure regarding (first) the establishment of terminal and transfer facilities, (second) the development and utilization of water power for industrial and commercial purposes, and (third) such other subjects as may be properly connected with such project: *Provided further*, That in the investigation and study of these questions consideration shall be given only to their bearing upon the improvement of navigation and to the possibility and desirability of their being coordinated in a logical and proper manner with improvements for navigation to lessen the cost of such improvements and to compensate the Government for expenditures made in the interest of navigation: *And provided further*, That the investigation and study of these questions as provided herein may, upon review by the Board of Engineers for Rivers and Harbors when called for as now provided by law, be extended to any work of improvement now under way and to any locality the examination and survey of which has heretofore been, or may hereafter be, authorized by Congress.

Surveys directed.

Review by board.
Vol. 34, p. 1118.

Provisos.
Additional information required in reports.

Scope of investigations.

Extension to other works.

Depth of waters. The depth of water in tidal waters, as well as in rivers and nontidal channels, whenever referred to in this Act shall be understood to mean the depth at mean low water unless otherwise expressed.

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(73)

Mar. 2, 1907.
Vol. 34, p. 1240.

CHAP. 2555.—An Act Permitting the building of a dam across the Savannah River at Andersonville Shoals.

[H. R. 25848.]
[Public, No. 214.]

Savannah River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the J. R. Earle Development Company, a cor-

poration to be organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River, extending from a point in Hart County, Georgia, to a point in Anderson County, South Carolina, upon or in the vicinity of Andersonville Shoals, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six. J. R. Earle Development Co. may dam, at Andersonville Shoals. Vol. 34, p. 386.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, March 2, 1907.

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(74)

CHAP. 2553.—An Act Permitting the building of a dam across the Savannah River at Calhoun Falls. Mar. 2, 1907. Vol. 34, p. 1240.

[H. R. 25846.] [Public, No. 212.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Hugh MacRae Company, a corporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River extending from a point in Elbert County, Georgia, to a point in Abbeville County, South Carolina, upon or in the vicinity of Calhoun Falls, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six. Savannah River. Hugh MacRae Co. may dam at Calhoun Falls. Vol. 34, p. 386.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, March 2, 1907.

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(75)

CHAP. 2580.—An Act Permitting the building of a dam across the Savannah River at Cherokee Shoals. Mar. 2, 1907. Vol. 34, p. 1255.

[H. R. 25849.] [Public, No. 239.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Hugh MacRae Company, a corporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River extending from a point in Elbert County, Georgia, to a point in Abbeville County, South Carolina, upon or in the vicinity of Cherokee Shoals, and all works incident thereto in the Savannah River, Ga., and S. C. Hugh MacRae Co. may dam, at Cherokee Shoals.

Vol. 34, p. 386.

utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Amendment.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, March 2, 1907.

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(76)

Feb. 8, 1901.
Vol. 31, p. 763.

[Public, No. 41.]

CHAP. 344.—An Act Permitting the building of two dams across the Savannah River above the city of Augusta in the State of Georgia.

Twin City Power Co. may dam Savannah River at Dortons Creek, S. C.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to Twin City Power Company, a corporation organized under the laws of the State of South Carolina, its successors or assigns, to construct, erect, and maintain a dam across the Savannah River at or near where Dortons Creek, in the county of Edgefield, State of South Carolina, empties into the Savannah River, and all works incident thereto in the utilization of the power thereby developed; and also a dam across the said river at or near the southern end of Prices Island in said river, and about five miles from the mouth of Dortons Creek, and all works incident thereto in the utilization of the power thereby developed: *Provided*, That each of the dams constructed shall be provided with an accessible lock of such capacity as may be prescribed by the Secretary of War: *Provided also*, That the plans for the construction and maintenance of said dams and appurtenant works shall be submitted to and approved by the Chief of Engineers and the Secretary of War before the commencement of the construction of such dam or dams, and that the said Twin City Power Company shall not deviate from such plans after such approval, either before or after completion of the same, unless the modification of said plans shall have previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *Provided further*, That in case any litigation arises from the building of said dam or dams, the maintaining of the same, or from the obstruction of said river by the said dam or dams or appurtenant works, cases may be tried in the proper courts as now provided for that purpose in the States of South Carolina and Georgia, and the courts of the United States.

—also at Prices Island, etc.

Provisos.
Locks.

Secretary of War to approve plans, etc.

Litigation.

Amendment.
Proviso.
Fishways.
Completion.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved: *And provided further*, That suitable fishways shall be constructed and maintained at said dams by said company, its successors and assigns,

as may be required from time to time by the United States Fish Commissioner.

SEC. 3. That this Act shall be null and void unless one of the said dams herein authorized shall be completed within five years from the passage of this Act, and unless both dams shall be completed within the same time the rights and privileges hereby granted shall cease and be determined so far as pertains to the incompleted dam: *And provided further*, That such dam or dams shall be constructed in such manner as not to injure or diminish the water power of any person or company having a dam or hydraulic works already constructed: *And provided further*, That before the construction of either of said dams compensation shall be made to any person or company whose lands may be taken or overflowed in the construction or maintenance of such dam or dams, in accordance with the laws of the State where said lands may be situate.

Provisos. No injury to existing hydraulic works.

Damages.

Approved, February 8, 1901.

CHAP. 2074.—An Act Authorizing the Twin City Power Company to build two dams across the Savannah River above the city of Augusta, in the State of Georgia.

Feb. 27, 1907. Vol. 34, p. 1000.

[S. 8182.] [Public, No. 134.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Twin City Power Company, a corporation organized under the laws of the State of South Carolina, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Savannah River, at or near where Dortons Creek, in the county of Edgefield, State of South Carolina, empties into the Savannah River, and also a dam across the said river at or near the southern end of Prices Island in said river and about five miles from the mouth of Dortons Creek in the State of South Carolina, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six: *Provided*, That one of said dams shall be completed within three years, and the other within five years from the passage of this Act.

Savannah River. Twin City Power Company may dam, at Dortons Creek and at Prices Island, S. C.

Vol. 34, p. 386.

Proviso. Time of construction.

SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Amendment.

Approved, February 27, 1907.

CHAP. 55.—An Act To authorize the Twin City Power Company to build, operate, and maintain three dams across the Savannah River, above the city of Augusta, in the State of Georgia.

Feb. 29, 1908. Vol. 35, p. 36.

[S. 3726.] [Public, No. 36.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Twin City Power Company, a corporation organized under the laws of the State of South Carolina, its successors and assigns, be, and they are hereby, au-

Savannah River. Twin City Power Company may dam.

Dortons Creek, S. C. thorized to construct, maintain, and operate a dam across the Savannah River, at or near where Dortons Creek, in the county of Edgefield, State of South Carolina, empties into the Savannah River, and also a dam across the said river at or near the southern end of Prices Island, in said river, and about five miles from the mouth of Dortons Creek, in the State of South Carolina, in accordance with the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six: *Provided*, That one of said dams shall be completed within three years and the other within five years from the passage of this Act.

Prices Island, S. C.

Vol. 34, p. 386.

Proviso.

Time of completion.

Crouchs Bluff. SEC. 2. That the said Twin City Power Company is authorized to construct, operate, and maintain a dam across the Savannah River at what is known as Crouchs Bluff, in Edgefield County, South Carolina: *Provided*, That the said site at Crouchs Bluff can be obtained by contract from the owners thereof: *And provided further*, That said dam at Crouchs Bluff shall be constructed under the provisions of the said Act of June twenty-first, nineteen hundred and six: *Provided further*, That said dam if constructed at Crouchs Bluff shall be completed within three years.

Provisos.

Site.

Vol. 34, p. 386.

Time of completion.

Repeal of former act. SEC. 3. That the Act entitled "An Act authorizing the Twin City Power Company to build two dams across the Savannah River, above the city of Augusta, in the State of Georgia," approved February twenty-seventh, nineteen hundred and seven, be, and the same is hereby, repealed.

Vol. 34, p. 1000.

Amendment. SEC. 4. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 29, 1908.

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(77)

Feb. 5, 1907. Vol. 34, p. 876.

[H. R. 21402.] [Public, No. 55.]

CHAP. 460.—An Act Permitting the building of a dam across the Savannah River at Gregg shoals.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Savannah River Power Company, a corporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River, extending from a point in Elbert County, Georgia, to a point in South Carolina near the dividing line between Anderson County, South Carolina, and Abbeville County, South Carolina, upon or in the vicinity of Gregg shoals, and all works incident thereto in the utilization of the power thereby developed in accordance with the provisions of an

Savannah River, Ga. and S. C.

Savannah River power Company may dam, at Gregg shoals.

Vol. 34, p. 386.

Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, February 5, 1907.

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(78)

CHAP. 2554.—An Act Permitting the building of a dam across the Savannah [Tugaloo] River at Hattons Ford.

Mar. 2, 1907. Vol. 34, p. 1240. [H. R. 25847.] [Public, No. 213.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Hugh MacRae Company, a corporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River, extending from a point in Hart County, Georgia, to a point in Anderson County, South Carolina, upon or in the vicinity of Hattons Ford, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Savannah (Tugaloo) River. Hugh MacRae Company may dam, at Hattons Ford. Vol. 34, p. 386.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, March 2, 1907.

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(79)

CHAP. 2549.—An Act Permitting the building of a dam across the Savannah River at McDaniel Shoals.

Mar. 2, 1907. Vol. 34, p. 1238. [H. R. 25778.] [Public, No. 208.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Anderson Guaranty and Trust Company, a corporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River extending from a point in Hart County, Georgia, to a point in Anderson County, South Carolina, upon or in the vicinity of McDaniel Shoals, and all works incident thereto in the utilization of the power thereby developed in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Savannah River. Anderson Guaranty and Trust Company may dam, at McDaniel Shoals. Vol. 34, p. 386.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved. Amendment.

Approved, March 2, 1907.

(80)

Mar. 2, 1907. Vol. 34, p. 1239. CHAP. 2551.—An Act Permitting the building of a dam across the Savannah River at Middleton Shoals.

[H. R. 25776.] [Public, No. 210.]

Savannah River. Anderson Guaranty and Trust Company may dam, at the Middleton shoals.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Anderson Guaranty and Trust Company, a corporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River extending from a point in Elbert County, Georgia, to a point in Anderson County, South Carolina, upon or in the vicinity of Middleton Shoals, and all work incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Vol. 34, p. 386.

Amendment.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, March 2, 1907.

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(81)

Mar. 2, 1907. Vol. 34, p. 1241. CHAP. 2556.—An Act Permitting the building of a dam across the Savannah River at Trotters Shoal.

[H. R. 25850.] [Public, No. 215.]

Savannah River. Hugh MacRae Company may dam, at Trotters shoals.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Hugh MacRae Company, a coroporation organized under the laws of South Carolina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River extending from a point in Elbert County, Georgia, to a point in Abbeville County, South Carolina, upon or in the vicinity of Trotters Shoals, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Vol. 34, p. 386.

Amendment.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved.

Approved, March 2, 1907.

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(82)

Mar. 2, 1907. Vol. 34, p. 1239. CHAP. 2550.—An Act Permitting the building of a dam across the Savannah River at Turner Shoals.

[H. R. 25774.] [Public, No. 209.]

Savannah River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Anderson Guaranty and Trust Company, a corporation organized under the laws of South Caro-

lina, its successors and assigns, is hereby authorized to construct and maintain a dam across the Savannah River extending from a point in Elbert County, Georgia, to a point in Abbeville County, South Carolina, upon or in the vicinity of Turner Shoals, and all works incident thereto in the utilization of the power thereby developed, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Anderson Guaranty and Trust Company may dam, at Turner shoals.

Vol. 34, p. 386.

SEC. 2. That the right to amend or repeal this Act is hereby expressly reserved.

Amendment.

Approved, March 2, 1907.

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(83)

CHAP. 10.—An Act To authorize the building of a dam across the Savannah River at or near the mouth of Stevens Creek, between the counties of Edgefield, South Carolina, and Columbia, Georgia.

Aug. 5, 1909.
Vol. 36, p. 180.

[H. R. 6277.]
[Public, No. 9.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That J. L. Hankinson, N. B. Dial, and their associates, their successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the Savannah River at or near the mouth of Stevens Creek, between the counties of Edgefield, South Carolina, and Columbia, Georgia, in accordance with the provisions of an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Savannah River.
J. L. Hankinson, N. B. Dial, etc., may dam.
Location.
Vol. 34, p. 386.

Approved, August 5, 1909.

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(84)

CHAP. 121.—An Act Authorizing the building of a dam across the Savannah River at Cherokee Shoals.

Feb. 18, 1911.
Vol. 36, p. 922.

[H. R. 31925.]
[Public, No. 396.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Hugh MacRae, M. F. H. Gouverneur, and E. W. Van C. Lucas, partners trading under the firm name of Hugh MacRae and Company, bankers, of the city of Wilmington, North Carolina, and their assigns, are hereby authorized to construct and maintain a dam across the Savannah River, at a point suitable to the interests of navigation, extending from a point in Elbert County, Georgia, to a point in Abbeville County, South Carolina, upon or in the vicinity of Cherokee Shoals, and all works incident thereto in the utilization of the power thereby

Savannah River.
Hugh MacRae & Co. may dam, at Cherokee Shoals, Ga.

Vol. 34, p. 886. developed, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Amendment. SEC. 2. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Former law repealed. Vol. 34, p. 1255. SEC. 3. That the Act of Congress approved March second, nineteen hundred and seven, entitled "An Act permitting the building of a dam across the Savannah River at Cherokee Shoals by the Hugh MacRae Company, a corporation organized under the laws of South Carolina," is hereby repealed.

Approved, February 18, 1911.

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(85)

Mar. 3, 1905. Vol. 33, p. 1006. [H. R. 15609.] [Public, No. 173.]

CHAP. 1440.—An Act Providing for the acquirement of water rights in the Spokane River along the southern boundary of the Spokane Indian Reservation, in the State of Washington, for the acquirement of lands on said reservation for sites for power purposes and the beneficial use of said water, and for other purposes.

Spokane River, Wash. Use of waters. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the right to the use of the waters of the Spokane River where the said river forms the southern boundary of the Spokane Indian Reservation may, with the consent of the Secretary of the Interior, be acquired by any citizen, association, or corporation of the United States by appropriation under and pursuant to the laws of the State of Washington.

Spokane Indian Reservation. Grant of lands of, for dams, etc. SEC. 2. That the Secretary of the Interior be, and he hereby is, authorized and empowered to grant such appropriator or appropriators land on said reservation, whether the same has been allotted in severalty to any individual Indians, but which has not been conveyed to the allottee with full power of alienation, or whether the same remains unallotted, on the north bank of the said Spokane River, such as shall be necessary and requisite for overflow rights and for the erection of suitable water, electrical, or power plants, dams, wing walls, flumes, or other needful structures required for the development of power or for the beneficial use of said water: * * *

Rules, etc. SEC. 5. That the Secretary of the Interior shall make all needful rules and regulations not inconsistent herewith for the proper execution and carrying into effect of this Act.

Approved, March 3, 1905.

(86)

[Extract from river and harbor act approved March 2, 1907.]

Mar. 2, 1907. Vol. 34, p. 1094.

[H. R. 24991.] [Public, No. 168.]

Improving Tennessee River at Colbert and Bee Tree shoals, Alabama: Continuing improvement, two hundred thousand dollars: *Provided*, That the Secretary of War may enter into a contract or contracts for such materials and work as may be necessary for the completion of said project, to an amount not exceeding two hundred and thirteen thousand dollars, exclusive of the amounts herein and heretofore appropriated or authorized. And the Secretary of War may appoint a Board of Engineers whose duty it shall be to examine the present condition of the United States canal and the Tennessee River from the head of Elk River Shoals to the Florence Railway bridge in the State of Alabama, with a view to permitting the improvement of the above-described stretch of said river by private or corporate agency in conjunction with the development of water power by means of not more than three locks and dams; and the said Board may examine any plans presented by such agency and shall report whether the same, if constructed, can, without injury to navigation, or with advantage thereto, be used to develop water power, and what portion, if any, of the expense of the work should be borne by the United States; and such Board shall report its findings not later than the first Monday in December, nineteen hundred and seven, and until such Board shall make its report and action shall be taken thereon by Congress no permits shall be issued under the provisions of the Act approved March sixth, nineteen hundred and six, entitled "An Act to authorize the construction of dams and power stations on the Tennessee River at Muscle Shoals, Alabama."

Colbert and Bee Tree shoals, Ala.

Proviso. Contract.

Board to examine conditions, etc.

Report.

Muscle shoals, permits withheld.

Vol. 34, p. 52.

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(87)

CHAP. 1605.—An Act To enable the Secretary of War to permit the erection of a lock and dam in aid of navigation in the Tennessee River near Chattanooga, Tennessee, and for other purposes.

Apr. 26, 1904. Vol. 33, p. 309.

[H. R. 15014.] [Public, No. 165.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, fully authorized and empowered to grant permission to the city of Chattanooga, Tennessee, or to a private corporation or company, or to individuals, as provided in section five of this bill, to build and construct a lock and dam across the Tennessee River at "Scott Point," near Chattanooga, Tennessee, under his direction, supervision, and control, and in accordance with and conformity to the plans and designs made by Major Dan C. Kingman, an engineer of the United States Army, in pursuance of

Tennessee River.

Chattanooga, Tenn., etc., authorized to build lock and dam.

Vol. 30, p. 1151. an Act of Congress passed on March third, eighteen hundred and ninety-nine, with such changes and modifications as the Secretary of War may direct: *Provided*, That the said contracting municipality or parties shall purchase and pay for all lands on either side of the river that may be necessary to the successful construction and operation of said lock and dam, including flowage rights and rights of way for ingress and egress from public highways, and deed the same to the United States, and make all excavations, erect all stone, concrete, and timber work, furnish all materials of every character, and pay for all labor employed in the construction of said lock and dam, and give said lock and dam to the United States completed, free of all cost, expense, claims, or charges of any kind whatsoever, except for expenses connected with the preparation of plans and the superintendence, as provided in section five of this Act, and further excepting the cost of the lock gates and ironwork and machinery necessary to operate the lock when completed, which shall be furnished by the United States.

Proviso. Conditions.

Time of construction.

SEC. 2. That the said municipality, corporation, company, or individuals undertaking the construction of said work shall begin the building of said lock and dam within eighteen months from the passage of this Act, and the same shall be completed within four years from the date of beginning the construction, the right being reserved to the United States to enter on the construction of said lock and dam if deemed advisable at any time before the work is commenced by said contracting parties; or if begun and not carried on in strict accordance with the directions of the Secretary of War, then the United States may assume the further construction and completion of said work at its option, the cost of such further construction and completion to be paid by the said contracting municipality, corporation, company, or individuals.

United States may construct.

Delivery of deed.

SEC. 3. That the deed to the United States to the land to be purchased and donated to the same, as mentioned in the first section of this Act, shall be executed and delivered within twelve months after the passage of this Act; and, further, that the Secretary of War shall determine from time to time whether the work is being properly done, and may require an increase in force to be employed by the contractor so as to force the work to completion within the limit mentioned in the Act.

Use of water power.

SEC. 4. That in consideration of the construction of said lock and dam, free of cost to the United States except as provided in section one of this Act, the United States hereby grants to the municipality, corporation, company, or persons constructing said lock and dam under the provisions of this Act such rights as it possesses to use the water power produced by said dam, and to convert the same into electric power or otherwise utilize it for a period of ninety-nine years: *Provided*, That

Proviso. Electric current to be supplied free to Government buildings, etc.

it or they shall furnish the necessary electric current while its or their power plant is in operation to move the gates and operate the locks and to light the United States buildings and grounds, free of cost to the United States: *And provided further*, That the plans for the necessary works and structures to utilize said water power shall be approved by the Secretary of War, and that nothing shall be done in the use of the water from said dam or otherwise to interfere with or in any way impede or retard the proper and complete navigation of the river at all times, nor in any way to interfere with the use and control of the same by the United States for the purposes of navigation: *And provided further*, That the Secretary of War is hereby authorized to prescribe regulations to govern the use of the said water power and the operations of the plant and force employed in connection therewith; and no claim shall be made against the United States for any failure of water power resulting from any cause whatever.

Unobstructed navigation.

Regulations.

SEC. 5. That it shall be the duty of the Secretary of War in contracting for the erection of the said lock and dam to give the preference, option, or first right to contract to do said work to the city of Chattanooga, Tennessee, but if said city of Chattanooga shall fail within four months from the passage of this Act to formally notify the Secretary of War of its intention to construct said lock and dam and to enter into contract to do so, then to C. E. James and J. C. Guild, residents of Chattanooga, Tennessee, their heirs and assigns. In case of failure on the part of said C. E. James and J. C. Guild, residents of Chattanooga, Tennessee, their heirs and assigns, for a further period of eight months to formally notify the Secretary of War of their intention to proceed with the construction of the lock and dam as herein provided, then it shall be lawful for the Secretary of War to contract with any private corporation, company, firm, or persons for the construction of said lock and dam on the terms and in the manner herein provided: *Provided*, That the Secretary of War may require the contracting party to execute a bond, with proper sureties, before the commencement of the work in such amount as he may consider necessary, not exceeding one hundred thousand dollars, to insure the commencement, prosecution, and completion of the work herein authorized and compliance with the terms, conditions, and requirements of this Act, and in case of failure to comply with the requirements of said bond the said contracting party shall forfeit to the United States the full amount thereof: *Provided further*, That the plans, including specifications and drawings for the work, shall be prepared at the expense of the United States, under the direction and subject to the approval of the Secretary of War and the Chief of Engineers, United States Army, by the officer of the Corps of Engineers, United States Army, having under his charge the work

Contract. Preference options.

***Provisos.* Bond.**

Plans, etc.

of improving the Tennessee River, who shall at the expense of the United States maintain a suitable force of inspectors upon the work to see that the plans and specifications are strictly carried out, and such conditions or safeguards as the Secretary of War and the Chief of Engineers may deem essential to securing proper results shall be made a part of the contract. The expense for plans as well as for the maintenance of the force of inspectors herein referred to shall be paid from the amount appropriated for preliminary examinations, surveys, contingencies, and so forth, made in section two of the river and harbor Act of June thirteenth, nineteen hundred and two.

Inspection.

Expense.

Vol. 32, p. 372.

Extension of time for construction.

SEC. 6. That in the event the city of Chattanooga undertakes the erection of said lock and dam the Secretary of War shall extend the time provided herein for beginning the work on the same for a period not exceeding twelve months from the passage of the enabling act that the general assembly of the State of Tennessee may pass at its next regular session, enabling said municipality to undertake said work, if the same be necessary; and in the same event he shall extend the time for the completion of said lock and dam twelve months.

Right of revocation reserved.

Indemnification.

SEC. 7. That the right is expressly reserved in the United States to revoke by Act of Congress the rights privileges, and benefits conferred by this Act; but in the event of such revocation the United States shall pay to the municipality, corporation, company, firm, or persons who may erect said lock and dam under the provisions of this Act, as full compensation, the reasonable value, exclusive of the franchise hereby conferred, of all properties erected and lands purchased by them necessary for the enjoyment of the benefits conferred upon them by the provisions of this Act, such value to be determined by mutual agreement between the Secretary of War and the owners of said properties, and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of said property, such proceedings to conform as nearly as may be to the laws of the State of Tennessee in respect of condemning land for the right of way for railroad purposes: *Provided*, That to insure compliance with the terms of the contract or of this Act, or to protect the interests of navigation, the Secretary of War shall have power at any time, before or after the completion of the work, to order a suspension of all privilèges granted by this Act: *And provided further*, That compliance with such order of suspension may be enforced by the injunction of the circuit court of the United States exercising jurisdiction in the district in which the work is situated, and proper proceedings to this end shall be instituted by the Attorney-General upon request of the Secretary of War.

Provisos.

Suspension of privileges.

Enforcement by injunction.

Existing laws not affected.

SEC. 8. That nothing in this Act shall be construed as in any way interfering with the exclusive jurisdiction

over and control by the United States of the Tennessee River and the lock and dam therein to be erected for the purpose of navigation, nor as repealing or modifying any of the provisions of law now existing in reference to the protection of navigation.

Approved, April 26, 1904.

CHAP. 32.—An Act To amend an Act approved April twenty-sixth, nineteen hundred and four, entitled "An Act to enable the Secretary of War to permit the erection of a lock and dam in aid of navigation in the Tennessee River near Chattanooga, Tennessee, and for other purposes."

Jan. 7, 1905.
Vol. 33, p. 603.
[H. R. 15590.]
[Public, No. 6.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act of Congress approved April twenty-sixth, nineteen hundred and four, entitled "An Act to enable the Secretary of War to permit the erection of a lock and dam in aid of navigation in the Tennessee River near Chattanooga, Tennessee, and for other purposes," be, and the same is hereby, amended by inserting in section one, line seven, after the words "Scott Point," "near Chattanooga, Tennessee," and before the word "under," the following: "or at such other point or place in the mountain section of said river below Scott Point as the Secretary of War may approve."

Tennessee River, Tenn. Construction of lock and dam in, near Chattanooga.
Vol. 33, p. 309.
Location.

Approved, January 7, 1905.

[Extract from river and harbor act approved March 3, 1905.]

Mar. 3, 1905.
Vol. 33, p. 1133.
[Public, No. 215.]

Improving Tennessee River, Tennessee: Continuing improvement by the partial construction of lock gates at the lock projected at or near Scotts Point, together with the cost of superintendence and the preparation of plans to be made by the United States, ten thousand dollars: *Provided*, That a contract or contracts may be entered into by the Secretary of War for such materials and work as may be necessary for the further prosecution of said work, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate forty thousand dollars exclusive of the amount here in appropriated.

Scott Point. Lock gates. (Hales bar.)
Proviso. Contracts.

[Extract from river and harbor act approved March 2, 1907.]

Mar. 2, 1907.
Vol. 34, p. 1093.
[Public, No. 168.]

Improving Tennessee River at Hales bar, Tennessee: Completing improvement, sixty-two thousand nine hundred and seventy dollars.

Hales bar, Tenn.

CHAP. 12.—An Act To amend an Act relative to the erection of a lock and dam in aid of navigation in the Tennessee River.

Aug. 5, 1909.
Vol. 36, p. 181.
[H. R. 11579.]
[Public, No. 11.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act of Congress entitled "An Act to enable the Secretary of War to permit the erection of a lock and dam in aid of navigation in the Tennessee River near Chattanooga, Tennessee, and for other purposes," ap-

Tennessee River. Time extended for lock and dam across, at Chattanooga, Tenn.

proved April twenty-sixth, nineteen hundred and four, and amended by an Act approved January seventh, nineteen hundred and five, be and the same is hereby amended as follows: Strike out in line four of section two of the Act of April twenty-sixth, nineteen hundred and four, after the word "Act," the following words: "And the same shall be completed within four years from the date of beginning the construction " and insert in place thereof the words: "And the same shall be completed within six years from the date of beginning the construction or within such time in excess thereof, as the Secretary of War may allow."

Vol. 33, pp. 309, 608, amended.

Approved, August 5, 1909.

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(88)

Mar. 6, 1906.
Vol. 34, p. 52.

[H. R. 297.]
[Public, No. 35.]

CHAP. 517.—An Act To authorize the construction of dams and power stations on the Tennessee River at Muscle Shoals, Alabama.

Tennessee River.
Dams at Muscle shoals, Ala., authorized.
Vol. 34, p. 1094.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any person, company, or corporation having authority therefor under the laws of the State of Alabama may hereafter erect, maintain, and use a dam or dams in or across the Tennessee River, in the State of Alabama, at such points at Muscle Shoals as they may elect, and the Secretary of War may approve, between a point on the southern side of the river opposite to, or below the head or opening of the canal constructed by the United States on the north side of the river, on the east, and the western line of section sixteen, township three, range ten on the west, for the purpose of erecting, operating, and maintaining power station and to maintain inlet and outlet races or canals and to make such other improvements on the southern bank of the Tennessee River, between the two points above mentioned, as may be necessary for the development of water power and the transmission of the same, subject always to the provisions and requirements of this Act, and to such conditions and stipulations as may be imposed by the Chief of Engineers and the Secretary of War for the protection of navigation and the property and other interests of the United States.

Construction, etc., of power stations.

Secretary of War to approve plans, etc.

SEC. 2. That detailed plans for the construction and operation of a dam or dams and other appurtenant and necessary works shall be submitted by the person, company, or corporation desiring to construct the same to the Chief of Engineers and the Secretary of War, with a map showing the location of such dam or other structures with such topographical and hydrographic data as may be necessary for a satisfactory understanding of the same, which must be approved by the Chief of Engineers and the Secretary of War before work can be commenced on

said dam or dams or other structures; and after such approval of said plans, no deviation whatsoever therefrom shall be made without first obtaining the approval of the Chief of Engineers and the Secretary of War: *Provided*, That the constructions hereby authorized do not interfere with the navigation of Muscle Shoals Canal or the navigation of the Tennessee River: *And provided further*, That said dam or dams and works shall be limited only to the use of the surplus water of the river, not required for the navigation of the Muscle Shoals Canal or the Tennessee River, and that no structures shall be built and no operations conducted by those availing themselves of the provisions of this Act which shall injure or interfere with the navigation of the Muscle Shoals Canal or impair the usefulness of any improvement made by the Government in the interests of navigation.

Provisos. Unobstructed navigation.

Restrictions.

SEC. 3. That the Government of the United States reserves the right, at any time that the improvement of the navigation of the Tennessee River demands it, to construct, maintain, and operate, in connection with any dam or other works built under the provisions of this Act, suitable lock or locks or any other structures for navigation purposes, and at all times to control such dam or dams or other structures, and the level of the pool caused by such dam or dams, to such an extent as may be necessary to provide facilities for navigation; and whenever Congress shall authorize the construction of such lock or other structures, the person, company or corporation owning and controlling such dam or dams or other structures shall convey to the United States, under such terms as Congress shall prescribe, titles to such land as may be required for the use of such lock and approaches, and in addition thereto shall grant to the United States, free of cost, the free use of water power for building and operating such constructions: *Provided also*, That the person, company, or corporation building, maintaining, or operating any dam or dams or other structures under the provisions of this Act shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise, in a court of competent jurisdiction. The person, company, or corporation owning or operating any such dam shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe.

Locks, etc.

Proviso.

Damages.

Lights, etc.

SEC. 4. That all the rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such right shall at any time fail to comply with any of the provisions or requirements of this Act, or with any of the stipulations that may be prescribed by the Chief of Engineers and the Secretary of War, or in case a person, company, or corporation authorized by the laws of the State of Alabama to erect and maintain a dam and improvements as contemplated by this Act shall fail to begin the erection of said dam

Failure to comply with stipulations, etc.

Time of construction. and improvements within two years after being so authorized and shall fail to complete the same within five years after obtaining such authority.

Existing rights not affected. SEC. 5. That the provisions of this Act shall in no manner interfere with or impair the rights of any person, company, or corporation heretofore authorized by Congress to erect a dam or other structures for the development of water power on the Tennessee River.

Amendment. SEC. 6. That the right to alter, amend, or repeal this Act is expressly reserved.

Approved, March 6, 1906.

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(89)

Mar. 3, 1899. Vol. 30, p. 1351. [Public, No. 201.]

CHAP. 437.—An Act Granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby given to the Muscle Shoals Power Company, a corporation created and organized under a charter granted by the legislature of the State of Alabama, its successors or assigns, to erect, construct, operate, and maintain inlet and outlet races or canals and a power station or stations at a point or points at or near the Muscle Shoals in Tennessee River, and to make such other improvements as may be necessary within said limits for the development of water power and transmission of the same: *Provided*, That the constructions hereby authorized do not in any way interfere with the Muscle Shoals Canal, or with navigation of said river: *Provided further*, That until the plans and location of the works herein authorized, so far as they affect the interests of navigation, have been approved by the Secretary of War, the improvements shall not be commenced or built, and the Secretary of War is authorized and directed to fix reasonable charges for use of said power.

Muscle Shoals Power Co. may construct canal, etc., at Muscle Shoals, Ala.

Provisos. No interference with Muscle Shoals Canal, etc.

Approval of Secretary of War.

Commencement and completion. SEC. 2. That unless the work herein authorized be commenced within one year and completed within three years from the date hereof, the privileges hereby granted shall cease and be determined.

Vols. 31, pp. 274, 846; 32, p. 839.

Amendment. SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 3, 1899.

June 6, 1900. Vol. 31, p. 274. [Public, No. 151.]

CHAP. 779.—An Act To amend an Act granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assem-

bled, That section two of an act entitled "An act granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama," approved March third, eighteen hundred and eighty-nine, be, and the same is hereby, amended so as to read as follows:

Muscle Shoals Power Co. canal and power stations. Vols. 30, p. 1351; 31, p. 846; 32, p. 839.

"SEC. 2. That unless the work herein authorized be commenced within two years, and completed within four years from the date hereof, the privileges hereby granted shall cease and be determined."

Time extended to complete work.

Approved, June 6, 1900.

CHAP. 672.—An Act To extend the time granted to the Muscle Shoals Power Company by an Act approved March third, eighteen hundred and ninety-nine, within which to commence and complete the work authorized in said Act to be done by said company.

Mar. 1, 1901. Vol. 31, p. 846.

[Public, No. 108.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time allowed the Muscle Shoals Power Company by section two of an Act entitled "An Act granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama," approved March third, eighteen hundred and ninety-nine, to commence and complete the work therein authorized to be done, be extended so that unless the work authorized to be done in said Act be commenced within two years and completed within four years from the date of this Act the privileges granted to said company by said first-mentioned Act shall cease and be determined.

Time extended to Muscle Shoals Power Co. to complete canal, etc., at Muscle Shoals, Ala.

Vol. 30, p. 1351.

Vol. 31, p. 274.

Vol. 32, p. 839.

Approved, March 1, 1901.

CHAP. 565.—An Act To extend the time granted to the Muscle Shoals Power Company by an Act approved March third, eighteen hundred and ninety-nine, within which to commence and complete the work authorized in the said Act to be done by said company, and for other purposes.

Feb. 18, 1903. Vol. 32, p. 839.

[Public, No. 96.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time allowed the Muscle Shoals Power Company by section two of an Act entitled "An Act granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama," approved March third, eighteen hundred and ninety-nine, to commence and complete the work therein authorized to be done be extended so that unless the work authorized in said Act to be done be commenced within two years and completed within four years from the date of this Act the privileges granted to said company by said first-mentioned Act shall cease and be determined; and the Secretary of War is authorized, in his discretion, to permit the said company to erect and construct dams which may abut on lands of the United States along the line of the Muscle Shoals Canal upon such terms

Muscle Shoals, Ala. Time extended for construction of canal, etc., by Muscle Shoals Power Co.

Vol. 30, p. 1351. Vol. 31, pp. 274, 846.

Construction of dams.

and conditions as may be deemed just and equitable to the public interests.

Approved, February 18, 1903.

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(90)

June 25, 1910.
Vol. 36, p. 828.

CHAP. 396.—An Act Authorizing the Lone Star Canal Company, of Anahuac, Chambers County, Texas, to erect a dam across the mouth of Turtle Bay, and for other purposes.

[H. R. 12858.]
[Public, No. 278.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Lone Star Canal Company, of Anahuac, Chambers County, Texas, be, and hereby is, authorized, under the supervision of the Secretary of War, to construct and maintain a bulkhead or dam across the mouth of Turtle Bay, north of Browns Pass of the Trinity River, commencing on the mainland abutting on the property of said company, extending westwardly about one thousand nine hundred feet to a point three hundred feet north of the mouth of said Browns Pass, abutting on state land: *Provided*, That said company shall, at its own expense, provide and keep a lock in said bulkhead or dam at such place and of such dimensions as may be approved by the Secretary of War.

Turtle Bay, Tex.
Lone Star Canal Company may dam.
Proviso.
Lock.

Closing passes.

SEC. 2. That said company, under the supervision of the Secretary of War, is hereby authorized to close by dam all passes from the Trinity River to said Turtle Bay, also Jacks Pass, connecting Trinity River with Galveston Bay.

Ditch from Trinity River to Smiths Bayou.

SEC. 3. That said company, after it shall have acquired title to the right of way, shall have and is hereby granted authority to cut a ditch of such depth and dimensions as may be prescribed by the Secretary of War from the Trinity River, opposite the junction of Old and Trinity rivers, to Smiths Bayou.

Construction
Vol. 34, p. 386.
Ante, p. 2828.

SEC. 4. That the work herein authorized shall not be commenced until the plans therefor shall have been filed in the War Department, and that the said work shall be constructed under the provisions of the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, and the Act amendatory thereof, approved June, nineteen hundred and ten, so far as the same may be hereto applicable.

Amendment.

SEC. 5. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 25, 1910.

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(91)

Feb. 14, 1889.
Vol. 25, p. 670.

CHAP. 165.—An Act To authorize and empower the Mount Carmel Development Company to draw water from the Wabash River, or its tributaries, in the county of Wabash, and State of Illinois.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Mount Carmel Development Company, a corporation created and existing under the laws of the State of Illinois, be, and the same is hereby, authorized and empowered to construct and operate, during its corporate existence, a hydraulic canal from any point on the Wabash River above the lock and dam now in process of construction at the Grand Rapids of said Wabash River, or from any tributary of said river within the county of Wabash and State of Illinois, to any point on said river within the corporate limits of the city of Mount Carmel, Illinois; and to draw from said Wabash River or tributary thereof such supply of water as may be required for the purposes of such corporation: *Provided*, That such withdrawal be not detrimental to the interests of navigation and be subject to the direction and control of the Secretary of War.

Mount Carmel Development Co. may construct canal from Wabash River, Ill.

Proviso. To be controlled by Secretary of War.

Approved, February 14, 1889.

CHAP. 358.—An Act Authorizing the Mount Carmel Development Company to draw water from Wabash River at Grand Rapids, Wabash County, Illinois.

Feb. 12, 1901. Vol. 31, p. 785.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Mount Carmel Development Company, a corporation chartered by the State of Illinois as of the date of October twenty-sixth, nineteen hundred, be, and the same is hereby, authorized and empowered to draw, by canal, flume, or race, from the pool of the Grand Rapids dam of the Wabash River, in the county of Wabash and State of Illinois, such supply of water as may be necessary or required for the purposes of said corporation during the continuance of said corporation: *Provided*, That such withdrawal of water shall not be so great as to be detrimental to the navigation of said Wabash River, and shall be under the direction and control of the Secretary of War: *And provided further*, That the said corporation shall submit detailed plans, showing the location and method of construction of said canal, flume, or race, to the Secretary of War for approval; and until he shall approve the same the work hereby authorized shall not be commenced.

Mount Carmel Development Co. may draw water from Wabash River at Grand Rapids, Ill.

Provisos.—control of supply, etc.

Secretary of War to approve plans.

Approved, February 12, 1901.

[Extract from the river and harbor act of March 3, 1909.]

Mar. 3, 1909. Vol. 35, p. 819.

[H. R. 28243.] [Public, No. 317.]

SEC. 9. That the Act of Congress entitled "An Act to authorize and empower the Mount Carmel Development Company to draw water from the Wabash River, or its tributaries in the county of Wabash and State of Illinois," approved February fourteenth, eighteen hundred and eighty-nine, and the Act of Congress entitled "An Act authorizing the Mount Carmel Development Company to

Wabash River, Ill. Use by Mount Carmel Development Company revoked.

Vol. 25, p. 670, repealed. Vol. 31, p. 785, repealed. Licenses for power from government dam.

draw water from Wabash River at Grand Rapids, Wabash County, Illinois," approved February twelfth, nineteen hundred and one, be, and the same are hereby, repealed. And the Secretary of War is hereby authorized and empowered to grant leases or licenses for the use of the water power created by the government dam on the Wabash River at Mount Carmel, Illinois, at such a rate, and on such conditions, and for such periods of time, as may seem to him just, equitable, and expedient; the said leases or licenses to be limited to the use of the surplus water not required for navigation, and to a period not exceeding twenty years; and he is also empowered to grant leases or licenses, not exceeding twenty years, for the occupation of such land belonging to the United States on said river as may be required for mill sites or other industrial purposes not inconsistent with the requirements of navigation: *Provided*, That all moneys received under such leases or licenses shall be deposited in the Treasury of the United States, and an itemized statement thereof shall accompany the annual report of the Chief of Engineers.

Proviso. Deposit, etc., of receipts.

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(92)

June 28, 1906. Vol. 34, p. 536. [H. R. 18106.] [Public, No. 318.]

CHAP. 3564.—An Act Granting to the Batesville Power Company right to erect and construct canal and power stations at Lock and Dam Numbered One, upper White River, Arkansas.

White River, Ark. Batesville Power Company may construct canal, etc., at Lock and Dam No. 1 for power station.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby given to the Batesville Power Company, a corporation created and organized under a charter granted by the State of Arkansas, its successors or assigns, to erect, construct, operate, and maintain inlet and outlet races, canals, or other structures and a power station or stations at or near Lock and Dam Numbered One, upper White River, Arkansas, and to make such other improvements as may be necessary for the development of water power from Pool Numbered One, and the transmission or application of the same: *Provided*, That the constructions hereby authorized are not built on any lands belonging to the United States and do not in any way impair the usefulness of any improvement made by the Government for the benefit of navigation: *Provided further*, That in the operation of the aforesaid constructions the withdrawal of water from the river shall at all times be under the direction and control of the Secretary of War, and that until the plans and location of the works herein authorized, so far as they affect the interests of navigation, have been approved by the Secretary of War, the improvements shall not be commenced or built, and the Secretary of War is authorized and directed to fix from time to time reasonable charges to be paid by said company for the use of said power.

Provisos. Condition.

Control of water.

SEC. 2. That unless the work herein authorized be commenced within one year and completed within three years from the date hereof the privileges hereby granted shall cease and be determined. Time of construction.

SEC. 3. That the right to alter, amend, or repeal this Act is expressly reserved. Amendment.

Approved, June 28, 1906.

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(93)

CHAP. 3622.—An Act To enable the Secretary of War to permit the erection of a lock and dam in aid of navigation in the White River, Arkansas, and for other purposes.

June 29, 1906. Vol. 34, p. 628. [H. R. 18596.] [Public, No. 368.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and empowered to grant permission to J. A. Omberg, junior, to build and construct a lock and dam across the White River at such point above Lock Numbered Three, now built or being built by the United States, as may be approved by the Secretary of War, the said lock and dam to be constructed under his direction, supervision, and control, and in accordance with and conformity to the plans and designs as may be approved by the Chief of Engineers of the United States Army: *Provided*, That the plans and designs of the said structure shall be prepared by the said contracting party at his own expense; and the said contracting party shall purchase and pay for all lands on either side of the river that may be necessary to the successful construction and operation of said lock and dam, including flowage rights and rights of way for ingress and egress from public highways, and deed the same to the United States, and make all excavations, erect all stone, concrete, and timber work, furnish all materials of every character, and pay for all labor employed in the construction of said lock and dam, and give said lock and dam to the United States completed, free of all cost, expense, claims, or charges of any kind whatsoever.

White River, Ark. J. A. Omberg, jr., may build lock and dam across.

Proviso. Plans, etc.

Construction.

Transfer free of cost.

SEC. 2. That the said individual undertaking the construction of said work shall begin the building of said lock and dam within eighteen months from the passage of this Act, and the same shall be completed within two years from the date of beginning the construction, the right being reserved to the United States to enter on the construction of said lock and dam, if deemed advisable, at any time before the work is commenced by said contracting party; or if begun and not carried on in strict accordance with the directions of the Secretary of War, then the United States may assume the further construction and completion of said work at its option, the cost of such further construction and completion to be paid by the said contracting individual. Time of construction.

Deed.

SEC. 3. That the deed to the United States to the land to be purchased and donated to the same, as mentioned in the first section of this Act, shall be executed and delivered within twelve months after the passage of this Act; and, further, that the Secretary of War shall determine from time to time whether the work is being properly done, and may require an increase in force to be employed by the contractor, so as to force the work to completion within the limit mentioned in the Act.

Character of work.

Grant of water-power privileges.

SEC. 4. That in consideration of the construction of said lock and dam, free of cost to the United States except as provided in section one of this Act, the United States hereby grants to the person constructing said lock and dam under the provisions of this Act such rights as it possesses to use the water power produced by said dam and to convert the same into electric power or otherwise utilize it for a period of ninety-nine years: *Provided*, That he shall furnish the necessary electric current while his power plant is in operation to move the gates and operate the locks and to light the United States buildings and grounds free of cost to the United States: *Provided further*, That the said person shall operate and maintain the said locks, affording passage to all boats and craft desiring to use the same, but the Secretary of War, in the interest of navigation, may relieve him of this obligation: *And provided further*, That the plans for the necessary works and structures to utilize said water power shall be approved by the Secretary of War, and that nothing shall be done in the use of the water from said dam or otherwise to interfere with or in any way impede or retard the proper and complete navigation of the river at all times, nor in any way to interfere with the use and control of the same by the United States for the purposes of navigation: *And provided further*, That the Secretary of War is hereby authorized to prescribe regulations to govern the use of the said water power and the operations of the plant and force employed in connection therewith; and no claim shall be made against the United States for any failure of water power resulting from any cause whatever.

Provisos. Electric current.

Operating locks.

Secretary of War to approve plans, etc.

Regulations.

Failure to notify.

SEC. 5. That in case of failure on the part of said J. A. Omberg, junior, his heirs and assigns, for a period of twelve months to formally notify the Secretary of War of his intention to proceed with the construction of the lock and dam as herein provided, then it shall be lawful for the Secretary of War to contract with any private corporation, company, firm, or persons for the construction of said lock and dam on the terms and in the manner herein provided: *Provided*, That the Secretary of War may require the contracting party to execute a bond, with proper sureties, before the commencement of the work, in such amount as he may consider necessary, not exceeding one hundred thousand dollars, to insure the commencement,

New contract.

Proviso. Bond.

prosecution, and completion of the work herein authorized and compliance with the terms, conditions, and requirements of this Act; and in case of failure to comply with the requirements of said bond the said contracting party shall forfeit to the United States the full amount thereof.

Forfeiture.

SEC. 6. That the right is expressly reserved in the United States to revoke by Act of Congress the rights, privileges, and benefits conferred by this Act; but in the event of such revocation the United States shall pay to the corporation, company, firm, or persons who may erect said lock and dam under the provisions of this Act as full compensation the reasonable value, exclusive of the franchise hereby conferred, of all properties erected and lands purchased by them necessary for the enjoyment of the benefits conferred upon them by the provisions of this Act, such value to be determined by mutual agreement between the Secretary of War and the owners of said properties; and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of said property, such proceedings to conform as nearly as may be to the laws of the State of Arkansas in respect of condemning land for the right of way for railroad purposes: *Provided*, That to insure compliance with the terms of the contract or of this Act, or to protect the interests of navigation, the Secretary of War shall have power at any time, before or after the completion of the work, to order a suspension of all privileges granted by this Act: *And provided further*, That compliance with such order of suspension may be enforced by the injunction of the circuit court of the United States exercising jurisdiction in the district in which the work is situated, and proper proceedings to this end shall be instituted by the Attorney-General upon request of the Secretary of War.

Revocation.

Compensation for improvements.

Determining value of.

Provisos. Suspension of privileges.

Enforcement by injunction.

SEC. 7. That nothing in this Act shall be construed as in any way interfering with the exclusive jurisdiction over and control by the United States of the White River and the lock and dam therein to be erected for the purpose of navigation, nor as repealing or modifying any of the provisions of law now existing in reference to the protection of navigation.

Jurisdiction and existing law not affected.

Approved, June 29, 1906.

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(94)

CHAP. 36.—An Act Granting to the Ozark Power and Water Company authority to construct a dam across White River, Missouri.

Feb. 4, 1911. Vol. 36, p. 897.

[S. 10268.] [Public, No. 842.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assem-

White River, Mo. *bled*, That the Ozark Power and Water Company, a corporation organized under the laws of the State of Missouri, with principal offices in the city of Saint Louis, Missouri, its successors and assigns, be, and they are hereby, authorized to construct, maintain, and operate a dam across the White River at a point suitable to the interests of navigation at or near its northernmost point, in Taney County, Missouri, approximately ten miles downstream from the towns of Hollister and Branson and four miles upstream from the town of Forsyth, county seat of Taney County, in the State of Missouri, in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-first, nineteen hundred and six."

Ozark Power & Water Co. may dam, in Taney County.

Vol. 34, p. 386.

Amendment. SEC. 2. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, February 4, 1911.

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(95)

ADDITIONAL LEGISLATION.

Muskingum, Green, and Barren rivers.—In addition to the water-power privileges granted by the aforementioned acts, Congress, in the river and harbor acts of 1888 and 1890, authorizes and empowers the Secretary of War to grant leases or licenses for the use of the water power on the Muskingum, Green, and Barren rivers, as shown by the following extracts from those laws, to wit:

[Extract from river and harbor act of August 11, 1888: Muskingum River.]

Muskingum River, Ohio. Improving Muskingum River, Ohio: For the construction of a lock at Taylorsville and the reconstruction of the lock at Zanesville, pursuant to the report of the engineers, one hundred and two thousand dollars; and the Secretary of War is hereby authorized and empowered to grant leases or licenses for the use of the water powers on the Muskingum River at such rate and on such conditions and for such periods of time as may seem to him just, equitable, and expedient: *Provided*, That the leases or licenses shall be limited to the use of the surplus water not required for navigation. And he is also empowered to grant leases or licenses for the occupation of such lands belonging to the United States on said Muskingum River as may be required for mill-sites or for other purposes not inconsistent with the requirements of navigation; and all moneys received under such leases or licenses shall be turned into the Treasury of the United States, and the itemized statement thereof shall accompany the annual report of the Chief of Engineers.

Proviso. Water-power rights.

But nothing in this act shall be construed to affect any vested right, if such there be, of any lessee of water power on said river. Vested rights.

[Extract from river and harbor act of September 19, 1890: Green and Barren rivers.]

The Secretary of War is hereby authorized and empowered to grant leases or licenses for the use of the water-powers on the Green and Barren Rivers at such a rate and on such conditions and for such periods of time as may seem to him just, equitable, and expedient; said leases not to exceed the period of twenty years: *Provided*, That the leases or licenses shall be limited to the use of the surplus water not required for navigation. And he is also empowered to grant leases or licenses for the occupation of such lands belonging to the United States on said Green and Barren Rivers as may be required for mill-sites or for other purposes not inconsistent with the requirements of navigation; said leases or licenses not to extend beyond the period of twenty years; and all moneys received under such leases or licenses shall be turned into the Treasury of the United States, and the itemized statement thereof shall accompany the annual report of the Chief of Engineers. But nothing in this act shall be construed to affect any vested right, if such there be, of any lessee of water-power on said river.

Green and Barren rivers. Water-power leases. *Proviso.* Limited to surplus water. Mill-site leases. Moneys covered in. Report, etc. Vested rights.

Following is an extract from the river and harbor act of March 2, 1907, which relates, in part, to the subject of the utilization of water power, to wit:

[Waterway from Chicago to the Gulf.]

The Secretary of War may appoint a board of five members, to be composed of three members of the Mississippi River Commission, one of whom shall be the president of such commission, and two engineer officers of the United States Army, to examine the Mississippi River below Saint Louis and report to Congress, at the earliest date by which a thorough examination can be made, upon the practicability and desirability of constructing and maintaining a navigable channel fourteen feet deep and of suitable width from Saint Louis to the mouth of the river, either by the improvement of said river or by a canal or canals for part of said route. In its report the board shall cover the probable cost of such improvement, the probable cost of maintenance, and the present and prospective commerce of said waterway, both local and general, upstream as well as downstream, and the said board may consider in connection with the examination herein provided for, the survey of a proposed waterway from Chicago to Saint Louis, heretofore reported; it shall also report whether other plans of improvement can be devised by which the probable demands of traffic,

Board to examine and report on 14-foot channel, St. Louis to mouth of river. Scope.

present and prospective, can be adequately met, and the sum of one hundred and ninety thousand dollars, or so much thereof as may be necessary, is hereby appropriated for the making of such survey, of which amount only one hundred thousand dollars shall be available, unless in presenting a plan for such waterway it shall be necessary, in the judgment of said board, to make a survey for a lateral canal or canals; and the force, plant, and records of the Mississippi River Commission shall be available for the use of said board in making said examination; and said board shall also at the earliest date practicable report upon the following:

Subjects of report.

First. What depth of channel is it practicable to produce between Saint Louis and Cairo at low water by means of regulation works.

Second. What depth will obtain in such regulated channel at the average stage of water for the year.

Third. For what average number of days annually will fourteen feet of water obtain in such regulated channel.

Fourth. What increase of depth will be obtained over the natural flow of water in such regulated channel by an added volume of ten thousand cubic feet per second; also fourteen thousand cubic feet per second.

Fifth. And the board shall consider further the practicability of producing at all seasons of the year a depth of fourteen feet in such regulated channel by the aid of locks and dams similar to those projected and in use on the Ohio River improvement.

Sixth. And the said Board shall also report upon any water power which may be created in the portion herein directed to be surveyed, as well as in the proposed waterway from Saint Louis to Chicago heretofore surveyed, and the value thereof, and what means should be taken in order that the Government of the United States may conserve the same or receive adequate compensation therefor, and upon any lands which may be drained by the construction of either of said proposed waterways, and shall also report what steps, if any, shall be taken to cause the cost of the improvement to be defrayed, in whole or part, by means of such water power or lands.

[Extract from river and harbor act June 25, 1910.]

June 25, 1910.
Vol. 36, p. 630.

[H. R. 20686.]
[Public, No. 264.]

Saint Paul to Minneapolis.
Modified project.
Proviso.
Water-power leases.

Improving Mississippi River, from Saint Paul to Minneapolis: The modified project recommended by the Chief of Engineers in his report dated March third, nineteen hundred and ten, printed in House Document Numbered Seven hundred and forty-one, Sixty-first Congress, second session, is hereby adopted, and all future work on said improvement shall be prosecuted in accordance therewith: *Provided*, That in the making of leases for water power a reasonable compensation shall be secured to the United States and the rates as fixed shall be subject to revision by Congress.

Improving Mississippi River in Minnesota: Improving reservoirs at the headwaters of the Mississippi River: Completing improvement by constructing a canal between Lake Winnibigoshish and Leech Lake, in accordance with the report submitted in House Document Numbered Three hundred and sixty-three, Sixty-first Congress, second session, sixty-one thousand two hundred dollars.

Reservoirs at headwaters.
Canal.

STATUTES RELATING TO THE CONTROL OF WATER POWER WITHIN THE PUBLIC DOMAIN.

Up to the year 1866, the Federal Government had not, by any act of legislation, defined its policy with respect to the control of water courses. In all the Eastern States the common-law doctrine of riparian rights in the use of running water, subject to the public easement for navigation, had been fully recognized. At this time it was also true that the public domain of the Federal Government was practically confined to the Western States. In these States the doctrine of riparian rights had proven to be inapplicable, being inconsistent with the conditions there existing. As a matter of fact, the use of running water, being chiefly valuable for mining purposes, had been acquired by priority of appropriation and the doctrine of appropriation was fully recognized in the customs and uses of these localities. It had been common practice for those requiring the use of water to trespass upon the public domain for the purpose of diverting water from streams passing through such domain. It is evident that the Federal Government, being the riparian proprietor, under the common law, was entitled to the full benefit and use of all waters passing through or by such property.

In the year 1866, the right to the use of running water by prior appropriation had become so fixed in the policy of these western jurisdictions that Congress, in response to the evident requirements, enacted the act of July 26, 1866, thereby giving legislative authority for acquiring the use of water on the public domain by appropriation and also surrendering the control of water rights to the jurisdiction of the various States.

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Act of 1866.—Revised Statutes, section 2339.—"Whenever by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws and the decision of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person in the construction of any ditch or canal, injures or damages the possession of any settler on the public domain, the party committing such injury or damage, shall be liable to the party injured for such damage."

July 26, 1866.
Vol. 14, p. 253.

Rev. Stats., sec. 2339.
Vested rights by prior appropriation recognized.

(97)

July 9, 1870. Vol. 16, p. 218.

Rev. Stats., sec. 2340.

Patents, etc., subject to vested water rights.

Act of 1870.—Revised Statutes, section 2340.—"All patents granted, or preemption or homesteads allowed, shall be subject to any vested and accrued water-rights, or rights to ditches and reservoirs used in connection with such water-rights as may have been accrued under or recognized by the preceding section."

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The same principle was more fully confirmed in the Desert land act, approved March 3rd, 1877.

Mar. 3, 1877, vol. 19, p. 377.

Desert lands may be purchased.

Declaration.

Right to use water.

Water on public lands to be free.

Contents of declaration.

Perfection of title.

Limit to quantity of land purchasable.

"*Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled*, That it shall be lawful for any citizen of the United States, or any person of requisite age, 'who may be entitled to become a citizen, and who has filed his declaration to become such,' and upon payment of twenty-five cents per acre—to file a declaration under oath with the register and receiver of the land district in which any desert land is situated, that he intends to reclaim a tract of desert land not exceeding one section, by conducting water upon the same, within the period of three years thereafter: *Provided, however*, That the right to the use of water by the person so conducting the same, on or to any tract of desert land of six hundred and forty acres shall depend upon bona fide prior appropriation: and such rights shall not exceed the amount of water actually appropriated, and necessarily used for the purpose of irrigation and reclamation; and all surplus water over and above such actual appropriation and use, together with the water of all lakes, rivers and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes subject to existing rights. Said declaration shall describe particularly said section of land if surveyed, and, if unsurveyed, shall describe the same as nearly as possible without a survey. At any time within the period of three years after filing said declaration, upon making satisfactory proof to the register and receiver of the reclamation of said tract of land in the manner aforesaid, and upon the payment to the receiver of the additional sum of one dollar per acre for a tract of land not exceeding six hundred and forty acres to any one person, a patent for the same shall be issued to him. *Provided*, That no person shall be permitted to enter more than one tract of land and not to exceed six hundred and forty acres which shall be in compact form.

"SEC. 2. That all lands exclusive of timber lands and mineral lands which will not, without irrigation, produce some agricultural crop, shall be deemed desert lands, within the meaning of this act, which fact shall be ascertained by proof of two or more credible witnesses under oath, whose affidavits shall be filed in the land office in which said tract of land may be situated. **Desert lands defined.**

"SEC. 3. That this act shall only apply to and take effect in the States of California, Oregon, and Nevada, and the Territories of Washington, Idaho, Montana, Utah, Wyoming, Arizona, New Mexico and Dakota, and the determination of what may be considered desert land shall be subject to the decision and regulation of the Commissioner of the General Land Office." **Localities in which act to apply.**

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(99)

That it had become a fixed policy of the Federal Government to yield to the various states jurisdiction over water courses, subject only to the federal control for purposes of navigation, is evident from numerous subsequent enactments.

The Act of March 3rd, 1891, entitled: An Act to repeal timber culture laws, and for other purposes, provides, "The privilege herein granted shall not be construed to interfere with the control of water for irrigation and other purposes *under authority of the respective states and territories.*"

Also, The Forest Service Act of June 4th, 1897, "All waters of such reservations may be used for domestic, mining, milling or irrigation purposes *under the laws of the state wherein such forest reservations are situated.*"

Also the Act of February 26th, 1897, "The charges for water coming in whole or in part from reservoir sites used or occupied under the provisions of this Act *shall always be subject to the control and regulation of the respective states and territories in which such reservoirs are in whole or in part situate.*"

The full text of the last mentioned Act follows:

An Act To provide for the use and occupation of reservoir sites reserved. **Feb. 26, 1897. Vol. 29, p. 599.**

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That all reservoir sites reserved or to be reserved shall be open to use and occupation under the right-of-way Act of March third, eighteen hundred and ninety-one. And any State is hereby authorized to improve and occupy such reservoir sites to the same extent as an individual or private corporation, under such rules and regulations as the Secretary of the Interior may prescribe: *Provided*, That the charges for water coming in whole or part from reservoir sites used or occupied under the provisions of this Act shall always be subject to the control and regulation of the respective States and Territories in which such reservoirs are in whole or part situate. **[Public, No. 95.]** **Public lands. Rights of way, reservoir sites. Vol. 26, p. 1101.** ***Proviso.*** **Water charges.**

Approved, February 26, 1897.

(100)

The first important Act carrying into effect the policy of the government to establish forest reserves was enacted March 3rd, 1891, and was entitled "An Act to repeal timber culture laws, and for other purposes." Section 24 of this Act reads as follows:

Mar. 3, 1891. Vol. 26, p. 1095.

Forest reservations.

"Sec. 24 That the President of the United States may, from time to time, set apart and reserve, in any State or Territory having public land bearing forests, in any part of the public lands wholly or in part covered with timber or undergrowth, whether of commercial value or not, as public reservations, and the President shall, by public proclamation, declare the establishment of such reservations and the limits thereof."

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(101)

The above Act was amended on several occasions, and by an Act approved June 4th, 1897, the execution of all laws relating to the Forest Reserves was entrusted to the Secretary of the Interior. The relevant portions of this enactment, being a part of the Sundry Civil Appropriation Act, are hereafter set out:

June 4, 1897. Vol. 30, p. 34.

Vol. 26, p. 1095.

"* * * All public lands heretofore designated and reserved by the President of the United States under the provisions of the Act approved March fourth, eighteen hundred and ninety one, the orders for which shall be and remain in full force and effect, unsuspended and unrevoked and all public lands that may hereafter be set aside and reserved as public forest reserves under said Act, shall be as far as practicable controlled and administered in accordance with the following provision:

Forest reservation, when to be established.

"No public forest reservation shall be established, except to improve and protect the forest within the reservations, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States; but it is not the purpose or intent of these provisions, or the Act providing for such reservations, to authorize the inclusion therein of lands more valuable for the mineral therein, or for agricultural purposes, than for forest purposes.

Provision for protection against fire, etc.

Rules and regulations.

Penalty. Vol. 25, p. 166. R. S., sec. 5388, p. 1044.

"The Secretary of the Interior shall make provision for the protection against destruction by fire and depredation upon the public forests and forest reservations which may have been set aside or which may be hereafter set aside under the Act of March third, eighteen hundred and ninety one, and which may be continued; and he may make such rules and regulations and establish such service as will insure the objects of such reservations, namely, to regulate their occupancy and use and to preserve the forests thereon from destruction; and any violation of the provisions of this Act or such rules and regulations shall be punished as is provided for in the Act

of June fourth, eighteen hundred and eighty eight, amending section five thousand three hundred and eighty eight of the Revised Statutes of the United States.[1] * * * (pp. 34, 35).

"All waters on such reservations may be used for domestic, mining, milling, or irrigation purposes, under the laws of the State wherein such forest reservations are situated, or under the laws of the United States and the rules and regulations established thereunder * * *" (p. 36). Waters.

(102)

An Act approved February 15, 1901, entitled "An Act relating to rights of way through certain parks, reservations, and other public lands," authorized the Secretary of the Interior to grant rights of way through public lands for transmission lines, water conduits, and kindred constructions under such regulations as he might make.

Following is the act in full:

An Act Relating to rights of way through certain parks, reservations, and other public lands. Feb. 15, 1901. Vol. 31, p. 790. [Public, No. 64.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior be, and hereby is, authorized and empowered, under general regulations to be fixed by him, to permit the use of rights of way through the public lands, forest and other reservations of the United States, and the Yosemite, Sequoia, and General Grant national parks, California, for electrical plants, poles, and lines for the generation and distribution of electrical power, and for telephone and telegraph purposes, and for canals, ditches, pipes and pipe lines, flumes, tunnels, or other water conduits, and for water plants, dams, and reservoirs used to promote irrigation or mining or quarrying, or the manufacturing or cutting of timber or lumber, or the supplying of water for domestic, public, or any other beneficial uses to the extent of the ground occupied by such canals, ditches, flumes, tunnels, reservoirs, or other water conduits or water plants, or electrical or other works permitted hereunder, and not to exceed fifty feet on each side of the marginal limits thereof, or not to exceed fifty feet on each side of the center line of such pipes and pipe lines, electrical, telegraph, and telephone lines and poles, by any citizen, association, or corporation of the United States, where it is intended by such to exercise the use permitted hereunder or any one or more of the purposes herein named: *Provided*, That such permits shall be allowed within or through any of said parks or any forest, military, Indian, or other reservation only upon the approval of the chief officer of

Public lands. Rights of way through reservations, etc., authorized.

Width, etc.

Proviso. Approval of permit.

[1] The penalty referred to is a fine in the sum of $500, or imprisonment for one year, or both.

the Department under whose supervision such park or reservation falls and upon a finding by him that the same is not incompatible with the public interest: *Provided further*, That all permits given hereunder for telegraph and telephone purposes shall be subject to the provision of title sixty-five of the Revised Statutes of the United States, and amendments thereto, regulating rights of way for telegraph companies over the public domain: *And provided further*, That any permission given by the Secretary of the Interior under the provisions of this Act may be revoked by him or his successor in his discretion, and shall not be held to confer any right, or easement, or interest in, to, or over any public land, reservation, or park.

Telegraph lines, etc., permits.

R. S., sec. 5263.

Revocation of permit.

Approved, February 15, 1901.

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(103)

By an act approved February 1st, 1905, the duty of executing laws relating to forest reserves was transferred to the Secretary of Agriculture and is now under the immediate charge of the Forest Service.

Following is the text of the act:

Feb. 1, 1905. Vol. 33, p. 628.

An Act Providing for the transfer of forest reserves from the Department of the Interior to the Department of Agriculture.

[H. R. 8460.] [Public, No. 34.]

Be it enacted by the Senate and House of Representatives of the United States or America in Congress assembled, That the Secretary of the Department of Agriculture shall, from and after the passage of this Act, execute or cause to be executed all laws affecting public lands heretofore or hereafter reserved under the provisions of section twenty-four of the Act entitled "An Act to repeal the timber-culture laws, and for other purposes," approved March third, eighteen hundred and ninety-one, and Acts supplemental to and amendatory thereof, after such lands have been so reserved, excepting such laws as affect the surveying, prospecting, locating, appropriating, entering, relinquishing, reconveying, certifying, or patenting of any of such lands.

Forest reserves, control of transferred to Secretary of Agriculture.

Vol. 26, p. 1103.

Export of pulp wood, etc., from Alaska permitted.

SEC. 2. That pulp wood or wood pulp manufactured from timber in the district of Alaska may be exported therefrom.

Selection of forest rangers.

SEC. 3. That forest supervisors and rangers shall be selected, when practicable, from qualified citizens of the States or Territories in which the said reserved, respectively, are situated.

Water rights granted for mining, etc., purposes.

SEC. 4. That rights of way for the construction and maintenance of dams, reservoirs, water plants, ditches, flumes, pipes, tunnels, and canals, within and across the forest reserves of the United States, are hereby granted to citizens and corporations of the United States for

municipal or mining purposes, and for the purposes of the milling and reduction of ores, during the period of their beneficial use, under such rules and regulations as may be prescribed by the Secretary of the Interior, and subject to the laws of the State or Territory in which said reserves are respectively situated. Regulations.

SEC. 5. That all moneys received from the sale of any products or the use of any land or resources of said forest reserves shall be covered into the Treasury of the United States and for a period of five years from the passage of this Act shall constitute a special fund available, until expended, as the Secretary of Agriculture may direct, for the protection, administration, improvement, and extension of Federal forest reserves. Use of funds received from sale of products, etc.

Approved, February 1, 1905.

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(104)

Under the provisions of an Act passed June 25, 1910, the President has temporarily withdrawn many of the most valuable water-power sites from entry until a time may come when their development may be more adequately controlled. Following is the act:

An Act To authorize the President of the United States to make withdrawals of public lands in certain cases.

June 25, 1910.
Vol. 36, p. 847.

[H. R. 24070.]
[Public, No. 303.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President may, at any time in his discretion, temporarily withdraw from settlement, location, sale, or entry any of the public lands of the United States including the District of Alaska and reserve the same for water-power sites, irrigation, classification of lands, or other public purposes to be specified in the orders of withdrawals, and such withdrawals or reservations shall remain in force until revoked by him or by an Act of Congress. Public lands. Temporary withdrawals by President for power sites, irrigation, etc., authorized.

SEC. 2. That all lands withdrawn under the provisions of this Act shall at all times be open to exploration, discovery, occupation, and purchase, under the mining laws of the United States, so far as the same apply to minerals other than coal, oil, gas, and phosphates: *Provided*, That the rights of any person who, at the date of any order of withdrawal heretofore or hereafter made, is a bona fide occupant or claimant of oil or gas bearing lands, and who, at such date, is in diligent prosecution of work leading to discovery of oil or gas, shall not be affected or impaired by such order, so long as such occupant or claimant shall continue in diligent prosecution of said work: *And provided further*, That this Act shall not be construed as a recognition, abridgment, or enlargement of any asserted rights or claims initiated upon any oil or gas bearing lands after any withdrawal of such lands made prior to Mining rights continued. Exceptions. *Provisos.* Rights of bona fide oil or gas claimants. Status of prior claims.

Homestead, etc., settlements excepted.

the passage of this Act: *And provided further*, That there shall be excepted from the force and effect of any withdrawal made under the provisions of this Act all lands which are, on the date of such withdrawal, embraced in any lawful homestead or desert-land entry theretofore made, or upon which any valid settlement has been made and is at said date being maintained and perfected pursuant to law; but the terms of this proviso shall not continue to apply to any particular tract of land unless the entryman or settler shall continue to comply with the law under which the entry or settlement was made: *And provided further*, That hereafter no forest reserve shall be created, nor shall any additions be made to one heretofore created within the limits of the States of Oregon, Washington, Idaho, Montana, Colorado, or Wyoming, except by Act of Congress.

Restrictions on new forest reserves.

Reports of withdrawals to Congress.

SEC. 3. That the Secretary of the Interior shall report all such withdrawals to Congress at the beginning of its next regular session after the date of the withdrawals.

Approved, June 25, 1910.

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(105)

It being substantially admitted by Federal authorities that the Government no longer had jurisdiction over nonnavigable streams and that the control of water courses, even on the public domain, had passed to the several States, an attempt has been made to conserve such water resources for the purpose of securing their maximum beneficial use by establishing rules and regulations for the use of such parts of the public domain as were essential for dam and reservoir sites, canals, transmission lines, and for similar uses. By virtue of the authority of the acts already set out the Forest Service has established the following rules, as announced in the Use Book for 1911, issued December 28, 1910:

U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE.

Henry S. Graves, Forester.

THE USE BOOK.

REGULATIONS AND INSTRUCTIONS FOR THE USE OF THE NATIONAL FORESTS, AND MANUAL OF PROCEDURE FOR FOREST OFFICERS.

[Issued by the Secretary of Agriculture December 28, 1910.]

WATER POWER.

REGULATION L-1. Preliminary water-power permits will allow the occupancy of the lands of the United States within national forests for the purpose of securing the data required for an application for final permit and for such construction as may be necessary to preserve water appropriation during that period. Final water-power permits will allow the occupancy and use of such lands for the construction, maintenance, and operation thereon of works for the main purpose of the generation of electrical power. Preliminary or final permits for commercial water-power works or for noncommercial water-power works of a capacity in excess of one thousand (1,000) horsepower will be granted, extended, and renewed only by the Secretary of Agriculture. Permits for noncommercial water-power works of a capacity of one thousand (1,000) horsepower or less and for transmission lines not a part of any water-power works covered by a water-power permit will be granted, extended, and renewed by the district forester. The Secretary of Agriculture alone may revoke water-power permits.

REG. L-2. The term "noncommercial water-power works" will be applied to water-power works owned and used solely by the permittees for one or more of the following purposes: In the operation of their own mines or in the milling and reduction of ores therefrom; as auxiliary to irrigation works owned and operated by permittees; temporarily, in the construction of other works for which permission has already been granted the permittees; by municipalities for municipal purposes; or for such other miscellaneous uses not herein enumerated as may be determined by the Secretary of Agriculture to fall within this class. No charge will be made for the use and occupancy of lands for noncommercial water-power works. All other water-power works will be termed "commercial." (See regulation L-7 for charges.)

REG. L-3. Priority of application for a preliminary water-power permit shall be established by filing an application as prescribed in regulation L-9. Priority of application for a final water-power permit shall be established by filing an application as prescribed in regulation L-10. If an application for a final permit as prescribed by the said regulation is filed within the period required

in a preliminary permit, priority established thereunder shall be maintained, and with reference to priority such application for final permit shall relate back and be effective as of the date of the application for the preliminary permit. Priority shall be maintained only when the projects shown in the application for the final permit are within the approximate limits of diversion and discharge as shown in the application for the preliminary permit; priority shall be established for any projects outside these limits from the date of filing the application for final permit. Priority established under an application for final permit shall be lost if the applicant fails to return a duly executed stipulation, as prescribed in regulation L-12, within ninety (90) days from the date it is mailed by the district forester, unless such period is extended by written authority of the Secretary of Agriculture. Priority established under an application for preliminary permit shall be lost if the application for final permit, as prescribed in regulation L-10, is not filed within the time required in the preliminary permit. Priority established under an application for final permit shall be lost if the permit is revoked. No other application for a like use, covering in whole or in part the same lands, shall be accepted from the permittee whose priority of application is lost until the expiration of one year thereafter.

Reg. L-4 (amended July 10, 1911). No final water-power permit shall be issued if the works to be constructed thereunder will in any way physically interfere with works operated or constructed or to be constructed under a final water-power permit, nor will a final water-power permit be issued for the construction of works within an area covered by a prior preliminary permit until after the filing of final application or the loss of priority by the prior preliminary permittee. Successive preliminary permits may be issued covering the same water-power site, but in each successive preliminary permit it shall be specified that such permit is subordinate to any prior permit or permits still in effect, and shall not deprive any prior preliminary permittee of his prior right to obtain a final permit.

Reg. L-5. Occupancy and use of national forest lands is the sole privilege granted under a water-power permit. In the issuance of such permits no attempt will be made to adjudicate water rights, since water rights are acquired under State laws and adjudicated by the courts. Therefore no protests against the granting of an application, if based upon alleged lack of water rights, will be considered; nor, in general, will any allegation that the time of beginning or completion of construction has been or is delayed by litigation over water rights be accepted as a sufficient reason for granting any extensions of time.

Reg. L-6. Unless sooner revoked by the Secretary of Agriculture, a final water-power permit shall terminate at the expiration of fifty (50) years from the date of the

permit, and may then be deemed to be an application by the permittee for a new permit to occupy and use such lands as are occupied and used under the original permit, provided that the permittee shall, not less than two nor more than four years prior to the termination of the permit, formally notify the Secretary of Agriculture that it desires such new permit, and will comply with all laws and regulations at such time existing, regulating the occupancy and use for water-power purposes of lands of the United States within the national forests.

REG. L-7. The occupancy and use of lands of the United States within national forests under a preliminary or final water-power permit, other than noncommercial, shall be conditioned upon the payment of an annual charge, based upon the value for power purposes of such lands, and the measure of said value shall be the net power capacity of the works, as defined in regulation L-8, and the rates at which the charge shall be calculated shall be for each net electrical horsepower per annum as follows:

For the first year	$0.10
For the second year	.20
For the third year	.30
For the fourth year	.40
For the fifth year	.50
For the sixth year	.60
For the seventh year	.70
For the eighth year	.80
For the ninth year	.90
For the tenth and each succeeding year	1.00

The above rates per net electrical horsepower per annum shall apply to preliminary water-power permits, in accordance with the net power capacity of the works as estimated at the time of granting the preliminary water-power permit, and if the final application is made in accordance with the terms of the preliminary permit all payments made under the preliminary permit shall be credited to the permittee and be applied to the payment due at the time of granting the final permit and, or, to payments to become due thereafter; provided, however, that if the final permit provides for only a partial development of the project or projects protected by the preliminary permit then only a proportional part of such payments as may have been made under the preliminary permit will be applied on payments due or to become due under the final permit.

The above rates shall also apply to final water-power permits, and if the works are completed and operation is begun within the time specified in the stipulation executed by the permittee or any approved extension thereof, all payments made prior to such completion of construction and beginning of operation and all payments which have been credited upon the final permit shall be applied on payments due or to become due upon or after the date of such completion of construction and beginning of operation.

The minimum rate of ten (10) cents per net electrical horsepower per annum shall also apply upon the date of the completion of construction and beginning of operation, if the works are completed and operation is begun within the period specified in the stipulation executed by the permittee or in an approved extension thereof, and shall increase by ten (10) cents per net electrical horsepower per annum for each year thereafter until a rate of one dollar ($1) per net electrical horsepower per annum is reached, and shall then remain at that rate until the expiration of the permit.

The minimum rate of ten (10) cents per net electrical horsepower per annum shall apply proportionately to the fractional part of the calendar year succeeding the date of the granting of the preliminary permit and of the final permit, and the date of the completion of construction and beginning of operation, if the works are completed and operation is begun within the time specified in the stipulation executed by the permittee or any approved extension thereof, and also to the following full calendar year.

If the original permittee sells or transfers his improvements in accordance with regulation L-15 and a new permit is issued to the vendee or transferee, the subsequent annual charges shall be at the rates that would have been required under the original permit, and any advance payments made by the original permittee may be applied pro tanto on the new permit. If all or any part of the amounts due for charges as required in the preliminary permit shall, after due notice has been given, be in arrears for sixty days, then and thereupon the preliminary permit shall terminate and be void. If all or any part of the amounts due for charges as required in the final permit shall, after due notice has been given, be in arrears for six months, then and thereupon the final permit shall terminate and be void.

Nothing in this regulation shall be construed to alter or amend the rates or the methods of fixing the charges as specifically provided in any existing permit.

REG. L-8. The term "gross power capacity," as used in these regulations, shall mean the power capacity of the entire works to be constructed, maintained, and, or, operated in whole or in part, under the permit for which application is made; provided that the term "power capacity," as used in this regulation, shall mean estimated average annual station output in electrical horsepower, which, under continuous operation with reasonable load factor, is possible of development from all water available therefor, falling through effective head, with deductions for reasonable mechanical and electrical losses in generating machinery, and that the term "load factor," as used in this regulation, shall mean ratio of average output to maximum output.

The " net power capacity " upon which the charges are based (see regulation L-7) shall be determined by making the following deductions from the gross power capacity of the entire works:

(A) An amount bearing approximately the same ratio to the storage power of the reservoir or reservoirs, proposed to be constructed or maintained under permit, as the area of unreserved lands and patented lands within the flood lines of such reservoir or reservoirs bears to the total area within said flood lines, as of the beginning of each year.

(B) An amount bearing approximately the same ratio to the difference between the gross power capacity and the storage power as the length of the conduit or conduits, proposed to be constructed or maintained under permit upon unreserved lands and patented lands, bears to the total length from intake to powerhouse, of the conduit or conduits, as of the beginning of each year.

(C) From the gross power capacity remaining after deductions (A) and (B) have been made a further deduction shall be made which, in per cent, shall be calculated by multiplying the square of the distance of primary transmission in miles by the constant factor 0.001, but in no case shall deduction (C) exceed twenty-five (25) per cent.

The term " storage power," as used in these regulations, shall mean that part of the aforesaid gross power capacity which is made possible of development by the use of any reservoir or reservoirs to be constructed or maintained in whole or in part under permit. The word " conduit," as used in these regulations, shall include ditches, canals, flumes, pipe lines, and all other means for the conveyance of a flow of water.

If any part of the electric energy generated by the works constructed in whole or in part under permit is used by the permittee in the operation of its own mines, or in the milling or reduction of ores therefrom, or as auxiliary to irrigation works owned and operated by the permittee, or for such other miscellaneous uses as may be determined by the Secretary of Agriculture to fall within " noncommercial " use, the net power capacity upon which the charge for any year is to be calculated shall, before such calculation, be reduced by an amount bearing approximately the same ratio to the net power capacity as the amount of electric energy generated by the works and used for the above purposes bears to the total amount of energy generated by the works during the last preceding year.

If at any time not less than ten (10) years after the original or after the last preceding determination of the gross power capacity the permittee or the Secretary of Agriculture, on the ground of the inaccuracy, insufficiency, or inapplicability of the data upon which the

original or said last preceding determination of the gross power capacity was made, shall apply for or give notice of review of the original or last preceding determination, then and thereupon such review shall be taken by the Secretary of Agriculture and a redetermination of the gross power capacity and of the storage power shall be made, and thereupon the redetermined gross power and the redetermined storage power shall, for the purpose of determining the charges, and from the beginning of the next calendar year, be taken to be the gross power capacity of the works and the storage power of the reservoir or reservoirs.

The decision of the Secretary of Agriculture shall be final as to all matters of fact upon which the determination of the power capacity of the works and the storage power of the reservoir or reservoirs depend.

REG. L-9. All applications for preliminary permits to occupy and use the lands of the United States within national forests for the purpose of securing the data required for a final application for water-power works and for such construction as may be necessary to preserve water appropriation, shall be filed with the district forester of the district in which such lands are situated, and shall consist of the following:

(A) An application in triplicate on Form 58.

(B) A map on tracing linen and either one Van Dyke negative or three print copies, cut to a uniform size not larger than 28 by 40 inches and not smaller than 24 by 36 inches, with scale so selected as to show the entire project upon a single map, showing the approximate location of the dams, reservoirs, conduits, power houses or other works for which final application is to be made; each separate sheet of maps, estimates, and data shall be signed and dated by the applicant. If the proposed development is to be upon surveyed land, the map shall show for each reservoir site the distance and bearing of one extremity of the dam from the nearest existing corner of the public survey, and the approximate position and area of the flood line of the reservoir; for each conduit line, the distance and bearing of each terminus from the nearest existing corner of the public survey, and the approximate location and length of the conduit; and for each power-house site, the distance and bearing of one corner of the site from the nearest existing corner of the public survey, and the approximate area of the site. If on unsurveyed land, the distances and bearings may be taken from some natural feature that can be readily recognized upon the ground, as a stream junction for example, or from a permanent monument that can be readily found.

(C) A statement in triplicate, estimating the amount of water available for use and the total head at each proposed power house.

(D) Estimates in triplicate of the amount of power that may be developed at each proposed power house.

(E) Prima facie evidence, certified by the proper public officer, of the appropriation by the applicant or its predecessors of all the water which it is proposed to use in the operation of the works applied for.

Application must be made for the occupancy and use of such lands for a definite limited period only, which period will allow a reasonable time for the preparation and filing of the final application as prescribed in regulation L-10.

The time prescribed in the preliminary permit may, upon application, be extended by the Secretary of Agriculture if the completion of the final application has been prevented by unusual climatic conditions that could not reasonably have been foreseen or by some special or peculiar cause beyond the control of the permittee.

Although not required as an essential part of the application, a statement from the district or supervising engineer of the United States Reclamation Service, to the effect that the granting of the permit applied for will not interfere with any Government reclamation project, should be submitted with the application.

An application for a preliminary water-power permit filed with the district forester shall not be complete until the last map or paper required by this regulation shall have been filed in the form prescribed.

Reg. L-10. All applications for final permits to occupy and use the lands of the United States within national forests for commercial water-power works and for noncommercial water-power works of more than 1,000 electrical horsepower capacity shall be filed with the district forester of the district in which the lands are situated, and shall consist of the following:

(A) An application in triplicate on Form 60.

(B) Maps of location and plans of structures, both on tracing linen with either one Van Dyke negative or two print copies cut to a uniform size not larger than 28 by 40 inches and not smaller than 24 by 36 inches, with a graphical scale of not less than 6 inches in length drawn thereon. Separate sheets shall be used for maps of location whenever the whole survey can not be shown upon a single sheet. Each separate sheet of maps and plans shall contain the affidavit of the applicant's engineer and the applicant's certificate.

(1) The following maps and plans shall be filed for each reservoir which will be used as a part of the complete power project: (*a*) A contour map of each reservoir site, dam, and dam site on a scale of not more than 400 feet to the inch with a contour interval of not more than 10 feet. United States Geological Survey datum should be used where available. The maps shall show the reference lines for the initial point of the survey and all land subdivisions within the flood lines of the reservoirs, and the status of all such lands which are within the national forest, designating separately national forest land and

patented land. (*b*) Plans, elevations, and cross sections of the dams, showing spillways, sluiceways, or sluice pipes, the character of the material to be used, and the type of construction.

(2) The following maps and plans shall be filed for the entire length of each conduit which will be used as a part of the complete power project: (*a*) A contour map of the entire conduit location, except pressure lines, on a scale of not more than 400 feet to the inch, with contour interval of not more than 10 feet and a profile of the pressure lines. United States Geological Survey datum should be used where available. The contours shall cover either an area of 100 feet in width on each side of the center line of the conduit or a difference in elevation of at least 25 feet above and below the grade line of the conduit. This map shall show the transit line of the survey and the center line of the proposed final location of conduits, including curves between tangents, the reference line of the location of termini, all land subdivisions to be crossed by the conduit, and the distance, from the nearest section or quarter-section corner, of the intersection of the transit line with section lines. If such corners can not be found within a half mile of the line the fact should be noted upon the map and the tie may be omitted. This map shall also show the status of land within the national forest which will be crossed by the conduits, designating separately national forest land and patented land, what sections of the conduit will be in flume, ditch, tunnel, pipe, etc., and the grade of each section. (*b*) Plans, elevations, and cross sections of each type of conduit, showing material, dimensions, grades, flow, line, and capacity, and plans of intake works and forebays.

(3) The following maps shall be filed for all power-house sites which will be used as a part of the complete power project. Contour maps on a scale of not more than 50 feet to the inch with contour interval of not more than 5 feet, of all proposed power-house sites, showing connections between initial point of survey and the reference corner of the public survey, the proposed locations of power houses, other buildings, etc., and the status of the lands to be used, designating separately national forest land and patented land. This map shall also state the proposed type and probable number and rated capacity of the water wheels and generators to be used.

(4) The following maps shall be filed for such portions of transmission lines as lie within the exterior boundaries of a national forest: A map of the survey of the proposed final location of the center line of the transmission line on a scale of not more than 1,000 feet to the inch. This map shall show the reference lines for the location of termini when within the exterior boundaries or of intersections with national forest boundaries, all land subdivisions to be crossed by the transmission line, the distances, from the nearest section or quarter-section corner,

of the intersection of the survey lines with the section lines and the status of the lands to be crossed by the transmission line, designating separately national forest land and patented land.

(C) Copies of field notes in triplicate of the entire final location survey of conduits and transmission lines and the exterior boundaries of power-house and reservoir sites bearing the affidavit of the applicant's engineer and the applicant's certificate.

(D) Detailed estimate in triplicate of the amount of maximum, minimum, and average output of the proposed works in electrical horsepower at the generator switchboard, bearing the affidavit of the applicant's engineer and the applicant's certificate. This estimate shall be accompanied by a detailed statement in triplicate of the complete data upon which estimates are based, consisting of a statement of the amount of water appropriated, the estimated average amounts of water to be used from natural flow and from storage, stream measurements, run-off and evaporation records, total and effective heads, estimated efficiencies of machinery, and estimated load factor of the plant.

(E) Prima facie evidence, certified by the proper public officer, of the appropriation by the applicant or its predecessors of all the water which it is proposed to use in the operation of the works. If such evidence has been filed with a preliminary application only such additional evidence will be required as will cover appropriations or transfers subsequent to the date of the evidence filed with the preliminary application.

(F) Articles of incorporation, if a corporation, certified under the State seal, or articles of association or partnership, properly certified, and, if a corporation organized under the laws of a State or Territory other than the State or Territory in which the project is located, evidence of the right to operate within the State or Territory within which the works are to be located.

Maps and field notes shall designate by termini and length each conduit and transmission line, and by initial point and area each reservoir site and power-house site. The termini of conduits, the termini of transmission lines when within the exterior boundaries, the intersections of transmission lines with national forest boundaries, and the initial point of survey of power-house sites shall be fixed by reference of course and distance to the nearest existing corner of the public survey. The initial point of the survey of reservoir sites shall be fixed by reference of course and distance to the nearest existing corner outside of the reservoir by a line, or lines, that does not cross an area that will be covered with water when the reservoir is in use. When either terminus or a conduit, or intersections of transmission lines with national forest boundaries, or the initial point of the survey of a reservoir or power-house site is upon unsurveyed land, it shall be connected by

traverse with an established corner of the public survey, and the distance from the terminus or initial point to the corner shall be computed and noted on the map and in the affidavit of the applicant's engineer. When an established corner of the public survey is more than 2 miles distant, this connection may be with a natural object or a permanent monument which can be readily found and recognized and which will fix and perpetuate the position of the terminus or initial point. This map shall show the position of such point and shall give the course and distance to the terminus and initial point. The field notes shall give an accurate description of the natural object or monument and full data of traverse as required above. The affidavit of the applicant's engineer and the applicant's certificate shall state the connections.

Each separate original map, plan, set of field notes, estimates and data, evidence of water right, articles of incorporation and evidence of right to do business within the State, when required, shall be plainly marked "Exhibit A," "Exhibit B," etc., respectively, and referred to by such designation in the application. Maps and plans shall in addition be described in the application by their titles as "Exhibit A," map of location of, etc., "Exhibit B," plan of, etc. Duplicate and triplicate copies should be marked "Exhibit A, duplicate," "Exhibit A, triplicate," etc. Maps should be rolled for mailing and should not be folded.

An application for final permit filed with the district forester shall not be complete until the last map or paper required by this regulation has been filed in the form prescribed.

REG. L-11. Applications for permission to occupy and use the lands of the United States within national forests for noncommercial water-power works of 1,000 horsepower capacity or less shall be filed with the district forester of the district in which such lands are situated, shall be in writing, and shall be accompanied by:

(A) A map in triplicate showing the location of dams, reservoirs, conduits, power houses, and transmission lines or other works.

(B) Field notes of the survey in triplicate.

(C) Prima facie evidence, certified by the proper public officer, of the appropriation by the applicant or its predecessors of all the water which it is proposed to use in the operation of the works.

(D) A statement in triplicate of the amount of water to be diverted for use and the amount of power to be developed.

The map shall consist of one original on tracing linen and either one Van Dyke negative or two print copies, and shall be not larger than 28 by 40 inches or smaller than 24 by 36 inches, and may be of any convenient scale. If the proposed development is to be upon unsurveyed land the map shall show, for each reservoir site, the dis-

tance and bearing of the initial point of survey from the nearest existing corner of the public survey, the location of the flood lines of the reservoir, and its area; for each conduit line, the distance and bearing of each terminus from the nearest corner of the public survey, the location of the center line of the conduit, and its length; and for each power-house site, the distance and bearing of the initial point of survey from the nearest corner of the public survey, the location of the exterior boundaries of the site, and the area. If on unsurveyed land, the distances and bearings may, if the nearest existing corner of the public survey is more than two miles distant, be taken from some natural object or permanent monument that can be readily found and recognized, and which will fix and perpetuate the position of the terminus or initial point.

REG. L-12. Before a water-power permit for noncommercial water-power works of over 1,000 horsepower capacity shall be issued the permittee shall execute a stipulation to include such of the requirements enumerated in regulation L-13 as may be necessary to protect national forest interests. Stipulations will not be required for noncommercial water-power works of 1,000 horsepower or less, or for transmission lines not a part of any water-power works covered by a water-power permit.

REG. L-13. Before a final permit for commercial water-power works shall be issued the permittee shall execute and file with the district forester a stipulation:

(A) To construct its works on the locations shown upon and in accordance with the maps and plans filed with its final application for a water-power permit and to make no material deviation from said location unless and until maps and plans showing such deviation shall have been filed with the district forester and approved by the Secretary of Agriculture. (See regulation L-15.)

(B) To begin the construction of the works, or the several parts of the works, within a specified period or periods from the date of the permit for which application has been made, and thereafter to diligently and continuously prosecute such construction unless temporarily interrupted by climatic conditions or by some special or peculiar cause beyond the control of the permittee. The term "construction of the works" as used in this regulation shall be deemed and taken to mean only the actual construction of dams, conduits, power houses, transmission lines, or some permanent structure necessary to the operation of the completed works, and shall not include surveys or the building of roads and trails, or the clearing of reservoir sites or other lands to be occupied, or the performance of any work preliminary to the actual construction of the permanent works.

(C) To complete the construction and begin the operation of the works, or the several parts of the works,

within a specified period or periods from the date of the permit for which application has been made.

(D) To operate continuously for the generation of electric energy the works constructed and maintained in whole or in part under the permit, unless, upon a full and satisfactory showing that such operation is prevented by unavoidable accidents or contingencies, this requirement shall be temporarily waived by the written consent of the Secretary of Agriculture.

(E) That any approval by the Secretary of Agriculture of any alteration or amendment, or of any map or plan, or of any extension of time, shall affect only the portions specifically covered by such approval. And no approval of any such alteration, amendment, or extension shall operate to alter or amend, or in any way whatsoever be a waiver of any other part, condition, or provision of the stipulation.

(F) To pay annually in advance for the use and occupancy of the land such charges as may be required by the regulations of the Secretary of Agriculture. (Regulations L–7 and L–8.)

(G) To install and maintain in good operating condition accurate measuring weirs, gauges, and other devices approved by the Secretary of Agriculture, adequate for the determination of the natural flow of the stream or streams from which the water is to be diverted for the operation of the works and of the amount of water used from the natural flow in the operation of the works and of the amounts of water held in and drawn from storage, and to keep accurate and sufficient records, to the satisfaction of the Secretary of Agriculture, of the abovenamed measurements.

(H) That the books and records of the permittee in so far as they show the amount of electric energy generated by the works constructed or maintained, in whole or in part, under permit, or the amount of water held in or used from storage, or the stream flow or other data of the watershed furnishing water used in the generation of electric energy, shall be open at all times to the inspection and examination of the Secretary of Agriculture, or his duly authorized representative, and that the permittee will during January of each year make a return to the Secretary of Agriculture, under oath, of such of the records of measurements made by or in the possession of the permittee as may be required by the Secretary of Agriculture and for the year ending on December thirty-first preceding.

(I) That the works to be constructed and maintained under the permit will not be owned, leased, trusteed, possessed, or controlled by any device or in any manner so that they form part of, or in any way effect, any combination in the form of an unlawful trust, or form the subject of any contract or conspiracy to limit the output of electric energy, or in restraint of trade with foreign nations

or between two or more States or Territories, or within any one State or Territory in the generation, sale, or distribution of electric energy.

(J) To protect all Government and other telephone lines at crossings of and at all places of proximity to the transmission line and to maintain the line in such a manner as to prevent injury to stock grazing on the national forests.

(K) To clear and keep clear the land along the transmission line where it crosses national forest lands.

(L) To dispose of all brush and other refuse resulting from the clearing out or cutting of timber on the national forest lands to be occupied under the permit for which application is made.

(M) To build and repair roads and trails whenever any roads or trails are destroyed or injured by construction work or flooding under the permission applied for, and to build and maintain necessary and suitable crossings for all roads and trails which intersect the conduit, if any, constructed, operated, or maintained on the lands the occupancy and use of which is applied for.

(N) To pay for the full value of all merchantable timber upon national forest lands to be cut, injured, or destroyed.

(O) To pay full value for all damage to the national forests resulting from the breaking of or the overflowing, leaking, or seeping of water from the works to be constructed, maintained, or operated under the permission applied for, and for all other damage to the national forests caused by the neglect of the permittee or the employees, contractors, or employees of the contractors of the permittee.

(P) To sell electric energy to the United States, when requested, at as low a rate as is given to any other purchaser for a like use at the same time; provided, that the permittee can furnish the same to the United States without diminishing the measured quantity of energy sold before such request to any other customer by a binding contract of sale; and provided further, that nothing in this clause shall be construed to require the permittee to increase its permanent work or to install additional generating machinery.

(Q) To do all reasonably within its power to prevent and suppress forest fires on or near the lands to be occupied under permit.

REG. L–14. During the progress of construction amendments to maps of location or plans of structures will be required from the permittee if there is a physical interference with the use of lands granted by existing permits or pending applications, or if there is a material deviation from the maps or plans as originally filed, but no deviation will be considered material which involves a change of less than 10 per cent in the estimated gross capacity of the works. Any approval of an amendment

APPENDIX IX.

A COMPARISON OF AMERICAN AND EUROPEAN WATERWAYS WITH SPECIAL REFERENCE TO THE FACTORS INFLUENCING THE DEVELOPMENT OF WATER TRANSPORTATION.

BY MR. E. O. MERCHANT.

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A COMPARISON OF AMERICAN AND EUROPEAN WATERWAYS WITH SPECIAL REFERENCE TO THE FACTORS INFLUENCING THE DEVELOPMENT OF WATER TRANSPORTATION.

By Mr. E. O. MERCHANT.

I.

THE REVIVAL OF WATER TRANSPORTATION.

The history of inland water transportation may be divided into three periods. During the first period, which began with the sixteenth century and closed with the advent of railway building, the waterways furnished the principal means of transportation. Their only competitors were the pack horse and the highway or turnpike, and the advantage which they enjoyed often made them profitable enterprises. The second period was one of competition with the railways, which resulted in a marked decline of water transportation and generally left the waterways in a decadent condition. The third period is marked by the revival of water transportation, which began in France, Germany, and Belgium as early as 1870.

The first period was essentially one of canal building. In many cases it was less expensive to build canals along the banks of streams than to improve the streams themselves. Particularly was this the case in England, where the principal use of rivers seems to have been to supply water for the canals. When Brindley, the pioneer in canal building, was before a committee of the House of Commons, a member asked him for what purpose he apprehended rivers were created. He replied, "To feed navigable canals."[1]

The construction of canals on level ground had been common since the days of the Egyptians and Babylonians, but it was not until the invention of the chamber lock that it was possible for canals to overcome elevations. The discovery of this simple device led to the rapid spread of canal building throughout Europe. The movement first became prominent in France. The Canal de Briare, connecting the Seine with the Loire, was begun in 1605 and completed in 1642. The famous Languedoc Canal, now known as the Canal du Midi, connecting the Bay of Biscay with the Mediterranean, was begun in 1666 and finished in 1681. This was one of the greatest achievements during the reign of Louis XIV. It was 148 miles in length, and accommodated barges of 100 tons capacity. An elevation of 600 feet was overcome by means of numerous locks, and a further elevation was avoided by a tunnel 700 feet in length. This canal was constructed by private enterprise under a grant from the Government, as were almost all the canals in the early period. During the eighteenth century the

[1] J. Phillips, History of Inland Navigation (London, 1792,), p. 99.

French canal system was perfected. Less than 200 miles of new canals have been added since 1800.

Canal building began early in Holland, where the use of the lock was known even before it was employed in France. Many of the canals were originally constructed for drainage purposes and later, as the country developed, were also used for transportation. Practically the whole system was completed by the opening of the nineteenth century. Most of the Belgian and many of the German canals were also constructed before the year 1800.

The period of active canal building in England commenced with the opening of the Bridgewater Canal from Worsley to Manchester, July, 1761. The success of this enterprise furnished the impetus for further construction. About 1790 a mania for canal building developed. Within four years acts were passed providing for the construction of 81 different canal projects, and by the year 1800 practically the whole canal system, aggregating more than 1,000 miles, was completed. A few additions were made between the years 1800 and 1830, but since the latter date there has been no important construction, except the Manchester Ship Canal.

Canal building in the United States began soon after the close of the Revolutionary War. Washington was a pioneer in this movement and advocated numerous projects, some of which were later undertaken. The period of most rapid construction commenced about 1825, with the completion of the Erie Canal. The success of this enterprise aroused great enthusiasm for canal building. During the same year an act was passed in New York State, known as the great canal law, which provided for the survey of 17 new canal projects, aggregating many hundred miles in length.[1] The two Ohio State canals, connecting Lake Erie with the Ohio River, were also begun in 1825, and the Pennsylvania system of State canals, the purpose of which was to connect Philadelphia with Pittsburgh and the interior, was begun the following year. The Chesapeake & Ohio Canal was begun in 1828 and completed in 1850. Some of the anthracite tidewater canals in Pennsylvania and New Jersey were begun before 1825.

The canals constructed in Europe during this first period were for the most part of small capacity. Particularly was this the case in England, where considerable elevations had to be overcome. The majority of English canals have a depth of about 3½ feet. Thirty-five per cent of the total canal mileage will accommodate boats carrying from 18 to 30 tons, 58 per cent of boats carrying from 40 to 60 tons, while only 7 per cent will accommodate boats of greater capacity. The difficulty of overcoming elevations and of securing adequate water supply for their canals appears not to have daunted the courage of the pioneer canal builders. By means of staircases of locks, lifts, and even tunnels of considerable length they carried their canals from the seacoast to interior localities. On the Worcester & Birmingham Canal, between Worcester and Tardebigge, a distance of 16 miles, there are 58 locks, 30 of them in one flight. On the Huddersfield Narrow Canal, between Huddersfield and Ashton, there are 74 locks in 20 miles, and on the Rochdale Canal, between Manchester and Sowerby, there are 92 locks in 32 miles. Vertical lifts

[1] Report of the State Engineer and Surveyor of New York, 1905, Supplement, Vol. I, p. 763.

and inclined planes were also employed to overcome elevations where the water supply was not sufficient for lockages. Most of those devices have since been discarded. There are also 45 tunnels on the English canals, some of which are of considerable length. The longest tunnel is on the Huddersfield Narrow Canal and has a length of more than 3 miles. There are also 11 other canal tunnels having a length greater than 1 mile. Passage through these tunnels was generally accomplished by a process known as "legging." Two persons lying on their backs, one on each side of the boat, worked it along through by pushing with their feet against the side walls of the tunnel.[1]

The early canals in the United States were also of shallow draft and equipped with numerous locks and sometimes inclined planes. The Morris Canal, connecting the Delaware River with Newark, N. J., was perhaps the most difficult to construct. The elevation of 914 feet, from Newark to the summit level near Stanhope, a distance of 57 miles, was overcome by means of 12 inclined planes and 16 locks. The descent of 760 feet from the summit level to Phillipsburg on the Delaware River was accomplished by means of 11 inclined planes and 7 locks. The canal was built originally with a prism of small dimensions, being only 4 feet in depth and accommodating boats of less than 40 tons capacity.

Although the canals of the first period, as a rule, were scarcely more than ditches, many of them proved to be profitable undertakings. Until railway competition began they furnished the principal means of transportation and played a very important rôle in the prosperity and development of different countries. On the whole they appeared to have been more profitable in England than elsewhere, owing to the rapid industrial development that began during the latter part of the eighteenth century. Their profits were much greater than those of the railways have ever been. The Bridgewater Canal, which cost less than $1,000,000, yielded an annual revenue of nearly $400,000. Canal shares paid high dividends and sometimes sold at a premium of 100 per cent or more. The following table gives a few examples of the dividends and prices of canal shares in England during the year 1824:[2]

Canal.	Dividends.		Price.
	£	s.	
Trent and Mersey	75	0	£2,200
Loughborough	197	0	4,600
Coventry	44	0	1,300
Oxford	32	0	850
Grand Junction	10	0	290
Staffordshire & Worcestershire	40	0	960
Birmingham	12	10	350
Shropshire	8	0	175

One of the most profitable undertakings in this country was the Schuylkill Navigation, which connected the anthracite coal fields in Pennsylvania with Philadelphia. During the period 1829–1842 it paid dividends ranging from 9 to 24 per cent, and the shares of the canal rose from $50 to $175.[3] The Erie Canal was undoubtedly the

[1] Bradshaw's Canals and Navigable Rivers of England and Wales, pp. 10–16.
[2] Gentleman's Magazine, December, 1824, p. 575. In addition to these regular dividends, most of the companies also paid a bonus each year.
[3] Chester Lloyd Jones, The Economic History of the Anthracite Tide Water Canals, p. 130.

most successful of any of the State enterprises. Up to and including the year 1882, when all tolls were discontinued, it had returned to the State of New York $42,599,718 profits on an investment for construction and improvement of $49,591,853.[1] Another very profitable enterprise was the Delaware & Hudson Canal, connecting the anthracite coal fields of northern Pennsylvania with the Hudson River. In 1863 it paid as high as 34 per cent, and the next year would have paid more if the capital stock had not been increased. But these profits were derived more from the transportation and sale of coal which the company mined and sold in New York City than from the general transportation business.[2]

The period of railway building commenced about 1830. In Europe within 10 years competition between the railways and waterways became severe. This continued for the next 30 or 40 years, at the end of which time the waterways were generally left in a decadent condition. The first railroads often intersected the waterways and served as feeders. As soon, however, as parallel lines were built active competition began. The passenger traffic was the first to pass to the railways. In fact, many of the first railways were intended primarily for the purpose of transporting passengers, and their facilities for carrying freight were very limited. Following the loss of passenger traffic, the higher grade freight business, in which speed was an essential factor, was next to pass to the railways, and finally when the railways had amalgamated sufficiently to form through routes and to offer cheaper rates, they also secured most of the coarse, bulky traffic carried by the waterways.

In Germany the smaller streams and canals were the first to suffer a marked decline of traffic. The railways were not so successful in direct competition against the Rhine and Elbe, although the normal increase of traffic on these rivers was checked and for some years they barely held their own. Wherever a combination rail and water route came into competition with an all-rail route the tonnage fell off rapidly. From 1865 to 1879 the traffic of the competing railways increased 183 per cent, while that of the most prosperous navigation companies only increased 35 per cent.

In France as early as 1844 the superior advantages of the railways had attracted attention and proposals were made to substitute railways for the canals. From 1852 to 1858 the short, disconnected railway lines rapidly amalgamated to form the six large companies which now exist. The severe competion which resulted was most disastrous to the waterways, which did not effect a similar transformation. The Seine from Paris to Rouen lost three-fourths of its traffic; the Canal Bourgogne from Paris to Lyon lost one-half.[3]

In England the railways and canal companies began active competition about 1840. When the shareholders of the latter saw their profits dwindle, they became alarmed, and in various ways sought to compel the railways to buy them out. Parliament yielded to the popular clamor, and before the end of the year 1845 one-third of the total canal mileage fell into the hands of the railway companies. Some of the canals thus acquired were used for the roadbeds of new rail-

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[1] Report of the Committee on Canals of New York State, 1899, p. 151.
[2] Chester Lloyd Jones, The Economic History of the Anthracite Tide Water Canals, p. 87.
[3] Paul Leon, Fleuves, Canaux, Chemins des Fer., p. 13.

way lines or abandoned. Others were used for feeders. On almost all the traffic declined rapidly as the result of railway control or competition.

The period of active canal building in the United States ended with the panic of 1837. The depression which followed caused the failure of many speculative canal enterprises. Also by this time the railroad had demonstrated its usefulness, and people turned their attention to railway building with the same enthusiasm previously shown for canal enterprises. The first instance of competition between railways and waterways in the United States occurred in 1842 with the opening of the Reading Railroad, which at once began to compete for the coal traffic of the Schuylkill Navigation. Severe competition continued until 1849, when the railroad and the canal company entered into an agreement as to their charges. During this time the canal made extensive improvements, as a result of which it was able to lower its tolls to 3½ mills per ton-mile. Finally in 1879 the canal was leased to the Reading Railroad for a period of 999 years. Active competition between the Lehigh Valley Railroad and the Lehigh Canal began about 1856, but was not severe until 1859. The outcome was that the canal company finally sold out to its railroad competitor. In the course of a few years practically every one of the private canal companies in New York, Pennsylvania, and New Jersey passed into the hands of their railway competitors, and in Pennsylvania, owing to the dissatisfaction of the people with the results of canal construction and popular discontent caused by the heavy burden of debt incurred, the State system of canals during the period 1845 to 1859 was also sold to the railway companies.[1] New York and Ohio retained control of their principal State canals despite popular dissatisfaction which at times manifested itself. Since 1837 the aggregate length of the canals which have been abandoned is about 2,244 miles, representing an original investment of more than $80,000,000.[2]

In the southern part of the United States and also in the Mississippi Valley severe competition between the railways and waterways did not begin as a rule until after the close of the Civil War, when the short railway lines were amalgamated into through routes and were improved so as to greatly reduce the cost of transportation. The improvement of rivers by the Federal Government, which became more liberal during the seventies, enabled them to compete successfully with the railroads for a time. The commerce of the Mississippi River reached its maximum during the years 1880 to 1884, since which time a steady decline has occurred. Some of the rivers in the western part of the country have not yet experienced railway competition, and their traffic has increased steadily with the settlement of the country. But wherever railway competition has been encountered almost without exception a marked decline in river commerce has taken place. Only a very few streams with exceptional advantages have been able to show any increase in traffic.

Renewed interest in the development of water transportation began in France during the sixties and in Germany during the

[1] Report of the State Engineer and Surveyor of New York for 1905, Supplement, Vol. II, p. 1378.
[2] Report of the Commissioner of Corporations on Transportation by Water in the United States, Pt. I, p. 44.

seventies. In England, also, investigations were made about the same time and legislation passed to protect the waterways against railway competition. This renewed interest was due principally to a growing hostility toward the railways, which was engendered by discriminations, high rates, and lack of adequate service. In France in 1861 a congestion of traffic took place, which the railways were unable to handle and great losses resulted to shippers. Furthermore, the railways insisted that they could not make any further reductions in their rates. The high charges which they exacted wherever they enjoyed a monopoly caused much dissatisfaction and the people began to turn their attention to the possibility of relief which their neglected waterways might afford.

The agitation for waterway improvements in France resulted in the adoption of the Freycinet program in 1879, which provided for the taking over of most of the concessions, the improvement and standardization of the waterway system, and the construction of new canals, aggregating some 800 miles in length. The carrying out of this program would have meant an expenditure of nearly $140,000,000. But many of the projects then adopted have never yet been undertaken. From 1871–1905 extensive improvements were also made on the German waterways. The rivers were deepened and linked together with canals. And the largest expenditures for improvements in Belgium were made during the years 1870–1900, when the waterway system was enlarged and standardized to accommodate 300-ton barges.

The striking feature of this movement for the revival of water transportation in Germany, France, and Belgium was the nationalization of the waterways and large expenditures by the central Government upon their improvement and maintenance. Since 1879 France has acquired all but 158 miles of waterways, the principal exceptions being three short canals belonging to the city of Paris. Belgium has acquired all but about 17 per cent of her waterways. The ship canal from the Rupel to Brussels was constructed by a society of communes, and several of the other canals are still operated by private companies under concessions which have not yet expired. The German States have also taken over most of their waterways. The principal exception in Prussia is the new Teltow Canal, near Berlin, completed in 1906, which was built and is administered entirely by the district of Teltow.

Where the revival of water transportation is in progress the shallow-draft canals are being replaced by modern canals of standard dimensions. The old methods of towage by mule or by man power are now being superseded by towing steamers or electric tractors. Terminals are being built and equipped with the latest appliances. Better types of boats and barges are being used. The tendency also is to make use of rivers whenever their improvement is practicable, rather than to construct lateral canals.

The growth of water transportation in Germany, France and Belgium during the last four decades has been phenomenal. From 1875–1909 the traffic on the German waterways increased 433 per cent. During the period 1880–1909 the traffic on the French waterways increased over 90 per cent, and in Belgium, during the years 1890–1907, the traffic on the inland waterways increased almost 115

per cent. The following table shows in parallel columns the growth of traffic in these three countries:[1]

Year.	Germany.[2]	France.	Belgium.
	Tons.[3]	*Tons.*[3]	*Tons.*[3]
1875	13,600,000		
1880		18,000,000	
1890		24,167,000	25,242,000
1895	30,000,000	27,174,000	30,242,000
1900	46,600,000	32,446,000	38,178,000
1905	67,000,000	34,030,000	53,345,000
1907		34,702,000	54,164,000
1909	73,357,000	35,624,000	

[1] Compiled from Lindley and from the annual statistics of these countries.
[2] The figures usually given for Germany are much larger than these since they include total receipts and shipments. In 1909 they amounted to 118,495,448 tons. But they could not be compared with those of France and Belgium from which all duplications have been removed.
[3] In these three countries the metric tons of 2,204.6 pounds is meant.

While the statistics for Russia are not so complete, it is reported that during the last decade water-borne traffic has increased 100 per cent. In Austria-Hungary during the same period the traffic on the inland waterway system has increased about 10 per cent.

The growth of traffic on the inland waterways of France, Germany and Belgium has been more rapid than the growth of traffic on the railways, and this notwithstanding the fact that the length of the waterway systems has scarcely increased while that of the railways has increased about 25 per cent in Belgium, 50 per cent in France, and 100 per cent in Germany. During the period 1875–1909 the rail tonnage in Germany increased about 350 per cent; in France during the period 1880–1907 it increased about 72 per cent; while in Belgium during the last two decades the increase of traffic on the railways has been about 62 per cent.

The importance of water transportation in Germany is shown by the fact that at several of the largest inland cities the receipts and shipments by water are nearly as large as those by rail. Since 1885 the waterways focusing at Berlin have carried from 40 to 50 per cent of the total receipts and shipments.[1] Until recently the receipts by water have exceeded those by rail. At Hamburg the receipts by river are nearly equal to those by rail, while the shipments by river are several times those by rail, as shown by the following table:

Receipts and shipments from Hamburg.[2]

Year.	Rail.		River.	
	Receipts.	Shipments.	Receipts.	Shipments.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1900	2,360,877	1,306,414	2,606,920	3,457,214
1905	2,865,154	1,697,773	3,001,172	4,643,465
1908	3,357,477	1,879,246	3,082,776	5,622,724

[1] Paul Goehts, Berlin als Binnenschiffahrts-Platz. In Staats-und-Social-Wissenschaft Forschungen Heft, 147 (1910), p. 111.
[2] National Waterways Commission Document No. 19, pp. 81 and 82.

In collecting tonnage statistics both for the railways and waterways in Germany the country is divided for convenience into what are known as traffic districts. Inasmuch as these are the same for both agencies of transportation, the opportunity is afforded for making comparisons between their respective receipts and shipments.

The following table shows a number of examples where the water traffic is almost as large, if not larger, than that transported by rail. The first district includes Hamburg.

Receipts and shipments in traffic districts for the year 1909.[1]

	Receipts.	Per cent.	Shipments.	Per cent.	Total.	Per cent.
Lower Elbe, Geesthacht and vicinity:	*Tons.*		*Tons.*		*Tons.*	
Rail	4,898,238	48.8	3,541,897	40.9	8,440,135	45.2
Water	5,129,766	51.2	5,111,115	59.1	10,240,881	54.8
Berlin and suburbs:						
Rail	13,274,424	55.1	3,627,062	86.4	16,901,486	59.8
Water	10,812,659	44.9	572,401	13.6	11,385,060	40.2
Duisburg-Ruhrort:						
Rail	16,393,262	77.3	6,064,011	30.2	22,457,273	54.4
Water	4,822,761	22.7	14,018,210	69.8	18,840,971	45.6
Mannheim and Ludwigshafen:						
Rail	2,224,538	21.6	4,059,776	68.9	6,284,314	38.8
Water	8,074,222	78.4	1,830,996	31.1	9,905,218	61.2

[1] Statistik des Deutschen Reichs, Band 235, I, 1909, Part I, pp. XII and XIII.

If either the receipts or shipments by rail and by water of some particular commodities such as coal are compared, it will be found that the waterways sometimes handle as much as 90 per cent of the traffic. This is especially true of the coal receipts at a number of Rhine ports, such as Mannheim, Gustavsburg, Rheinau and Strassburg and of coal shipments at Kosel on the Oder. It is also true of the receipts of sand, gravel, and building stone at Berlin and a number of other cities having a large population.

At some of the Belgian ports, particularly Bruges and Ghent, the receipts and shipments by water compare very favorably with those by rail. At Paris the waterways handle nearly half of the total receipts and shipments, as shown by the following table, which is for 1910:[1]

	Shipments.		Receipts.		Total.	
	Tons.	Per cent.	Tons.	Per cent.	Tons.	Per cent.
Waterways	2,357,712	44.0	6,563,749	47.0	8,921,461	46.0
Railways	3,016,911	56.0	7,389,065	53.0	10,405,976	54.0

There are also a number of cities in France where the waterways carry more than 30 per cent of the total traffic and more than 50 per cent of either the receipts or shipments, taken separately,[2] while for some particular commodities like coal, the shipments by water at Denain on the Escaut, Douai on the Scarpe, Bruay on the Canal d'Aire, and other cities in the coal-mining districts of northern France,

[1] Statistique de la Navigation Interieure, 1910, p. 127.
[2] Cf. Bulletin, International Railway Congress, Eng. ed., vol. 24, Part I, p. 1175.

greatly exceed those by rail. At some other ports, such as Bordeaux on the Saône and Lyon on the Rhone, the receipts of sand, gravel, and building stone by water exceed those by rail.

Holland has never nationalized her waterways to the extent that France, Germany, and Belgium have, the reason being that they have never encountered as severe railway competition nor experienced a similar decline in traffic. The waterways exceed the railways in mileage and, it is stated, carry 90 per cent of the total freight traffic. The river system in Holland, comprising about 560 miles, is under the supervision of the national Government, while the canal system, aggregating about 2,408 miles, is under the supervision of the following authorities:[1]

	Miles.
Under national authority	342
Under provincial authority	493
Under private companies	372
Under local authority	805
Under national and provincial authority	114
Under national and private authority	3
Under national and local authority	31
Under provincial and private authority	47
Under provincial and local authority	117
Under local and private authority	84
Total	2,408

The national Government maintains and improves the waterways under its supervision which are the most important, while the minor political subdivisions and private interests improve the remainder. The national Government also provides the entrances to harbors, while the municipalities furnish the docks and terminal facilities, except for several harbors of refuge which are owned by the Government.

England is the only one of the more advanced European countries in which inland water transportation is still in a backward condition. The canals were originally built by private interests and have remained under private control ever since. The tidal portions of the principal rivers are generally under the control of conservancy boards, representing the different municipalities. The central Government has never participated at all in the improvement of waterways except for two canals in Scotland and four waterways in Ireland. The different canals and navigations still remain disconnected and under the jurisdiction of a multiplicity of authorities. Since the opening of the period of railway building, 70 years ago, few of the waterways have been enlarged or improved to meet modern conditions. Almost all the through routes are blocked by railroad control of one or more important links. Not one of the 19 different through routes in England and Wales is controlled by a single body. On the three routes connecting London and Liverpool there are 26 different authorities, including those over the tidal portions of the Mersey, Severn, and Humber. On the four routes between London and Bristol there are 27 different authorities. On the shortest route between Hull and Bristol a boat must traverse 10 different waterways, with gauges varying anywhere from 50 by 14 by 4.6 feet to 212 by 22 by 9.6 feet.[2] Thus long-distance travel on the waterways is a practical impossibility.

[1] National Waterways Commission Document No. 18, p. 19.
[2] Forbes & Ashford, Our Waterways, p. 241.

Since 1870 there has been a gradual revival of interest in waterways, which has led to numerous parliamentary inquiries and various acts intended to prevent the railways from acquiring further canals and from allowing those which they have already acquired to deteriorate. The revival of interest in water transportation has also led to the building of the Manchester Ship Canal, completed in 1893.

During the last decade the agitation for a resuscitation of the waterway system has become more pronounced. In 1904, at the annual meeting of the Associated Chambers of Commerce at Manchester, the advisability of the Government's purchasing and improving the canal system was considered. In 1905 a canal trust bill, embodying the conclusions of the Manchester conference, was introduced in Parliament. This led to the appointment in 1906 of the royal commission on canals and inland waterways, which, after three years of investigation, has published its findings in 11 large volumes. The work of this commission undoubtedly represents the most thorough and complete study of water transportation in Europe yet undertaken. The commission recommends that the four principal routes popularly known as the "Cross," which connect the Midland, or Birmingham, district with the estuaries of the Thames, Mersey, Severn, and Humber, respectively, should be taken over by some public body, amalgamated, standardized, and in other respects improved so as to render them more efficient as a means of transportation. Although not definitely recommending it, the commission appeared to favor a type of canal accommodating barges of 100 tons capacity, and estimated that the improvement of 544 miles of canals, excluding water supply and incidental expenditures, would cost about $65,000,000. The additional expenditures would probably increase this amount by at least $20,000,000. No estimate was made of the cost of acquisition and unification. It is thought by some that it would bring the total up to $150,000,000. The commission recommended that a nonpartisan waterway board, composed of three or five commissioners, be created, with power to issue stock or raise loans guaranteed by the State, in order to obtain the capital necessary for the acquisition, unification, reconstruction, and improvement of the four main routes.

Thus far the recommendations of the commission have not been acted upon. The railways would offer great opposition to the adoption of such a plan, and it seems quite probable that the nationalization of the railway systems will be necessary before the Government can secure control, at a reasonable price, of the canals now in the possession of the railway companies.

In the United States, as elsewhere stated, most of the canals in the eastern part of the country are owned or controlled by the railways, while all the navigable rivers have always been under the jurisdiction of the United States. Formerly it was customary for States or private companies to construct canals around rapids in rivers and to canalize streams. Sometimes they were assisted by land grants from the Federal Government or a guaranty of their bonds. Since about 1870, however, the Federal Government has acquired all the connecting links in the Great Lakes and all the canalized rivers and canals around rapids of navigable streams. In 1887 the Government

took over the Muskingum River from the State of Ohio, at a cost of $1,500,000. In 1875 the State of West Virginia transferred to the United States all rights which it had on the Great Kanawha River and its tributaries. The locks and dams in the Little Kanawha River were purchased by the Government from a private company in 1906. The Monongahela River locks and dams were purchased under condemnation proceedings from a private company in 1896. The Louisville & Portland Canal around the falls of the Ohio, near Louisville, was taken over by the Federal Government in 1864. It had previously been under the control of a private company, with a grant from the State of Kentucky. The St. Marys Falls Canal, between Lake Superior and Lake Huron, was transferred by the State of Michigan to the United States in 1880. The Federal Government, however, has not undertaken to nationalize State and private canals as has been done in France.

In this country we have a very striking contrast presented—the remarkable growth of water transportation on the Great Lakes and the decadent condition of commerce on many of the rivers and canals. The records kept by the engineers in charge of the locks in the two canals which connect Lake Superior with Lake Huron furnish the best index of the growth of commerce on the Great Lakes. In 1885 the traffic amounted to 3,256,628 tons; in 1910 it had increased to 62,363,218 tons, a gain of almost 2,000 per cent. In 1911 the traffic decreased to 53,477,216 tons, owing to dull times and poor crops. This record of growth surpasses that of any of the waterways in Europe and is only possible on large bodies of water of this kind.

The growth of commerce at a number of the Great Lake ports has been very rapid. At the present time the receipts and shipments at the combined harbors of Duluth and Superior exceed those of any other port in the country with the possible exception of the port of New York. In 1900 the total receipts and shipments at Duluth alone amounted to 7,089,441 tons. In 1906 they had risen to 14,424,101. Since then the commercial statistics of Duluth and Superior have been combined. During the season of navigation in 1910 the total receipts and shipments of the two harbors amounted to 36,684,580 short tons, valued at $284,000,000.

Some of the Lake Michigan ports have a large and rapidly increasing traffic. In 1910 the total receipts and shipments at Milwaukee amounted to 7,744,985, an increase of 100 per cent during the last decade. On the other hand, the commerce at Chicago, although large, has shown practically no increase since the year 1899. In 1910 the total receipts and shipments at Chicago and South Chicago amounted to 11,527,621 tons.

At some of the Lake Erie ports the growth of traffic has been especially marked. The total receipts and shipments at Cleveland were 5,201,357 tons in 1895 and 13,386,606 tons in 1910, an increase of 260 per cent. The receipts and shipments by lake, while not so large, nevertheless compare very favorably with those by rail, as shown by the table following.[1]

[1] Report of the Commissioner of Corporations on Transportation by Water, Part II, p. 233. The rail receipts and shipments for 1910 were obtained from the Cleveland Chamber of Commerce and the lake receipts and shipments from the Monthly Summary of Commerce and Finance, December, 1910.

Years.	Receipts.		Shipments.	
	Lake.	Rail.	Lake.	Rail.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1895	3,593,044	6,100,143	1,608,313	4,270,152
1900	4,769,720	8,867,904	2,548,826	5,839,071
1905	6,749,262	11,255,011	3,494,866	8,974,067
1910	8,051,121	13,700,312	5,335,485	8,921,630

Ashtabula is at present one of the greatest transfer ports on Lake Erie. In 1895 the receipts and shipments amounted to 3,735,982, in 1900 to 5,248,938, in 1905 to 7,897,093, and in 1910 to 16,257,723 short tons, a gain of 450 per cent in 15 years. Fairport, Conneaut and Erie also have a large traffic, which is increasing rapidly. At Buffalo the total receipts and shipments by Lake and Erie Canal in 1910 amounted to 16,290,423 tons, valued at $431,784,982, as compared with 11,642,862 tons in 1896.

It is very difficult to determine the actual condition of river traffic for the reason that the statistics which have been collected are very incomplete and unsatisfactory. Where a stream has locks and dams, it is possible for the engineers in charge to obtain fairly good statistics of the traffic that passes through, but where there is open river navigation, accurate tonnage statistics are difficult to obtain. Oftentimes they are nothing more than guesses. During the last few years there has been considerable improvement noticeable in the collection of these statistics, and they are much more reliable than formerly. Attempts are now made in the case of many streams to give the valuation of the traffic, and also, where possible, to give the ton-mileage, but, on the whole, we are far behind France, Germany, and Belgium in this particular. One of the worst defects from the standpoint of the student of water transportation is the lack of coordination of tonnage statistics. There is no way of knowing what the actual tonnage for each stream as a whole is where it is of any length, for the reason that statistics of receipts and shipments are not always collected at every landing and as a rule do not include any information regarding the points to which freight is destined or from which it is received. Hence only in a few cases is it possible to remove the duplications that occur. Not having complete statistics for each waterway, it is, of course, impossible to compute by years the total water-borne traffic for all of the streams in the country as is done in Europe.

Such statistics as are obtainable for the rivers in the United States indicate that few streams during the last two decades have shown any great increase in traffic, while many have shown a decided decline. The rivers showing the largest increase are those estuaries or arms of the sea which furnish ship channels or harbors for the important seaports on the Atlantic, Gulf, or Pacific coasts. In Table No. 1 a few examples are given. Most of these rivers have a depth of 20 feet or more. The figures in the first column represent the average annual tonnage for the years 1890–1895 wherever obtainable; those in the second column are averages for the years 1906–1908; and those in the third column are for the year 1910.[1]

[1] The figures in the first two columns are taken from National Waterways Commission Document No. 15; those for 1910 are taken from the Annual Report of the Chief of Engineers, 1911. The following tables are compiled in the same way.

No. 1.—*Examples of increasing traffic.*

Project.	Traffic 1890-1895 (yearly average).	Traffic 1906-1908 (yearly average).	Traffic in 1910.	Increase over average for 1890-1895.	Harbor.
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Mystic River (lower section)	[1] 1,430,650	3,723,000	3,245,630	1,814,980	Boston.
Providence River	1,305,000	3,128,000	4,662,638	3,357,638	Providence.
Harlem River	3,002,000	9,656,000	12,822,855	9,820,855	New York.
Passaic River	1,000,000	2,577,000	2,366,291	1,366,291	Newark.
Delaware River	13,121,000	26,259,000	25,496,213	12,375,213	Philadelphia.
Patapsco River	3,243,000	8,441,000	[2] 9,806,421	6,563,421	Baltimore.
Cape Fear River	220,000	870,000	944,657	724,657	Wilmington.
St. John's River	567,000	2,115,000	1,736,919	1,169,919	Jacksonville.

[1] Statistics are for 1901, the first year separated from Boston Harbor. [2] Fiscal year 1911.

There are also a number of other streams of less depth emptying into the Atlantic Ocean, which because of their proximity to large cities have had a steadily increasing traffic. These are located principally along the New York, New Jersey, Delaware, and Maryland coast. The most important of these are shown by the following table:

No. 2.—*Other examples of increasing traffic.*

Project.	Traffic 1890-1895 (yearly average).	Traffic 1906-1908 (yearly average).	Traffic in 1910.	Increase over average for 1890-1895.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Weymouth Fore River	68,000	153,000	186,303	118,303
Bronx River	179,000	361,000	456,756	277,756
East Chester Creek	13,000	280,000	378,400	365,400
Shrewsbury River	568,000	1,718,000	1,608,600	1,040,600
Mispillion River	47,000	202,000	191,745	144,745
Choptank River	13,000	210,000	237,273	224,273
Nanticoke River	17,000	120,000	136,569	119,569
Wicomico River	74,000	200,000	227,428	153,428

Table No. 3 gives some examples of streams emptying into the Atlantic Ocean, on which there has been a noticeable decline in commerce since 1890. It will be noted that in several instances an improvement has taken place since the years 1906–1908. This is particularly true of the Hudson River between Troy and Coxsackie. In 1907 the traffic on this section of the river was 2,881,168 tons. Since that time there has been an increase of more than 2,000,000 tons, so that the commerce now is as large as for the period 1890–1895.

No. 3.—*Examples of decreasing traffic.*

Project.	Traffic 1890-1895 (yearly average).	Traffic 1906-1908 (yearly average).	Traffic in 1910.	Decrease from average 1890-1895.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Penobscot River	840,000	740,000	566,434	273,566
Kennebec River	1,140,000	550,000	412,793	727,207
Taunton River	488,000	193,000	137,284	350,716
Connecticut to Hartford	1,041,000	532,000	636,874	404,126
Hudson, Troy to Coxsackie	5,000,000	3,000,000	5,033,360	+33,360
Raritan and South	1,594,000	889,000	963,470	630,530
Manokin River	144,000	59,000	....	....
York River	306,000	169,000	186,947	119,053
James River	699,000	563,000	627,684	71,316
Roanoke River	150,000	74,000	53,989	96,011
Oconee River	109,000	105,000	[1] 10,667	98,333
Ocmulgee River	115,000	74,000	[1] 12,523	102,477

[1] Rafted lumber is excluded. It would add in each case about 60,000 tons.

If we turn to the Mississippi River system and other streams in the interior of the country, we find only a few instances of a large as well as increasing traffic, and these are confined almost entirely to the Ohio and some of its tributaries, especially the Monongahela.

No. 4.—*The Ohio River and tributaries.*

Project.	Traffic 1890-1895 (yearly average).	Traffic, 1906-1908 (yearly average).	Traffic in 1910.	Increase over average for 1890-1895.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Ohio	7,355,000	11,965,000	11,112,216	3,757,216
Monongahela	4,407,000	11,143,000	10,927,430	6,520,430
Allegheny	794,000	1,613,000	2,235,015	1,441,015
Kanawha	1,237,000	1,579,000	1,295,930	58,930

Some additional examples of a large increase in traffic for streams not included in the table above are shown by Table No. 5. In almost every instance, however, as will be seen, there was a noticeable falling off in traffic during the year 1910. This is due in most cases to the decline in the lumbering industry resulting from the depletion of forests. Unless the traffic in some other commodities increases sufficiently to offset the losses in lumber products, a further decline may be looked for on these streams.

No. 5.—*Examples of increasing traffic.*

Project.	Traffic 1890-1895 (yearly average).	Traffic, 1906-1908 (yearly average).	Traffic in 1910.	Increase over average for 1890-1895.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Alabama	68,000	294,000	108,373	40,373
Tombigbee, mouth to Demopolis	49,000	372,000	182,358	133,358
Bayou Plaquemine	118,000	604,000	742,716	624,716
Cumberland, below Nashville	47,000	258,000	327,757	280,757
Cumberland, above Nashville	73,000	319,000	188,067	115,067
Tennessee, below Riverton	296,000	690,000	464,030	168,030

The greatest decline in traffic has occurred on the Mississippi River and some of its tributaries. The Mississippi was formerly a great highway of commerce from the interior of the country to the Gulf port of New Orleans, but except for some local traffic has now been practically abandoned as an agency of transportation. Regarding this feature the New Orleans Picayune makes the following statement:

> The abandonment of this great natural national free waterway for all purposes of commerce is one of the most surprising facts in the history of trade, and no such spectacle has appeared or been recorded in any other country.

The following table shows the decline of traffic on the Mississippi for different sections. If the Ohio River coal traffic were subtracted from the tonnage given, the average movement of freight would probably be less than 400,000 tons downstream and 300,000 upstream.

No. 6.—*The decline of Mississippi River traffic.*

Project.	Traffic, 1890-1895 (yearly average).	Traffic, 1906-1908 (yearly average).	Traffic in 1910.	Decrease.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Minneapolis to St. Paul	455,000	300,000	120,000	335,000
St. Paul to Missouri River	3,558,000	4,181,000	1,836,035	1,721,965
Missouri River to the Ohio	1,119,000	460,000	289,759	829,241
Cairo to Memphis	[1] 2,306,000	1,702,099	1,039,195	1,266,805
Memphis to Vicksburg	[1] 1,856,339	1,756,510	980,386	875,953
Vicksburg to New Orleans	[1] 1,835,174	2,335,842	1,530,230	304,944

[1] These figures are for 1901, the first year when the traffic is reported by sections. If corresponding figures for 1890 were obtainable, they would undoubtedly be much larger.

Much has been said of the great traffic carried on the Mississippi River during the seventies and eighties. Although efforts have often been made to arrive at some estimate of the amount of this traffic, they have never been wholly successful, owing to the fact that during those years few statistics were collected. The following table, taken originally from the census report of 1890, however, throws some light on the magnitude of the river commerce at that time and indicates that during the last two decades the Mississippi has lost approximately two-thirds of its former commerce.[1]

Traffic on the Mississippi River system in 1889.

	Number of vessels.	Freight tonnage.	Miles traveled.
Upper Mississippi River system	613	6,260,448	1,424,655
Lower Mississippi River system	572	6,232,087	2,311,573
Ohio River system	6,245	15,796,968	3,579,233
Total	7,430	28,289,503	7,315,461

When the Passes of the Mississippi were opened in 1879 to admit vessels of 26 feet draft, the grain traffic on the river increased enormously. Probably the best index of this grain traffic is shown by the shipments at St. Louis. In 1880, 15,762,644 bushels of wheat were sent down the river from St. Louis to New Orleans. This was approximately one-third of the total grain shipments from St. Louis. Large quantities of grain were also shipped by water at St. Paul, Peoria, Rock Island, and other river ports. The total receipts and shipments by river at St. Louis reached their maximum during the years 1880 and 1881, amounting to slightly more than 2,000,000 tons. The following table shows the decline in traffic at St. Louis since those years.[2]

[1] Census Report on Transportation by Water, 1906, p. 178; also see Annual Report of the Chief of Engineers, 1901, Supplement, p. 36.
[2] Cf. Annual Report of the Chief of Engineers, 1901, Supplement, p. 38.

Receipts and shipments at St. Louis.

Year.	Total receipts and shipments.	Total shipments.	Total grain shipments, rail and river.	Grain shipments by river.
	Tons.	*Tons.*	*Bushels.*	*Bushels.*
1880	2,130,525	1,038,350	48,321,983	15,762,664
1885	2,231,100	534,175	38,833,580	8,667,919
1890	1,281,715	617,985	65,155,187	10,217,244
1895	812,185	303,355	29,339,368	1,690,417
1900	757,590	245,580	54,606,499	3,506,491

The shipment of grain from St. Louis by river was suspended in 1903, when 2,749,441 bushels were sent down to New Orleans. A new company has recently been organized which intends to install a barge line on the river and reestablish the service from St. Louis to New Orleans.

Agitation for the improvement of waterways has been growing rapidly in the United States during the last decade, and has been especially marked since the boom years of 1906 and 1907, when the congestion of traffic and the failure of the railways to afford sufficient accommodations resulted in enormous losses to shippers in all parts of the country. At the present time there are no less than 30 waterway associations in the United States, 29 of which were organized for the purpose of promoting some particular project, while the National Rivers and Harbors Congress, composed of members from all parts of the United States, advocates "a policy and not a project." The principal aim of this association is to induce the Government to expend at least $50,000,000 a year for general waterway improvements throughout the United States.

The agitation for waterway improvements in this country, as well as in Europe, is based fundamentally upon the economic necessity of cheaper and more adequate transportation facilities, although at times less worthy motives, such as the selfish interest of localities or individuals, the zeal of politicians in securing appropriations for their districts, or hostility to the railways, may appear to predominate. This same fundamental cause has led to the improvement and utilization of waterways on the Continent and is behind the present agitation for waterway improvements in England, where, as the result of high railroad rates, industries have been compelled to move to the seaboard in order to maintain themselves against foreign competitors. It is stated that the cost of transporting freight to London or Liverpool from a city 50 miles in the interior is greater than to bring the same traffic there from the heart of Germany or Belgium.

Thus far the renewed interest in the possibilities of water transportation has had little result beyond inducing the Federal Government to expend larger sums for channel improvements. Some States, such as New York, are making efforts to revive the use of their waterways and some municipalities are assuming control and improving their terminal facilities. While an increase of commerce is noticeable on a few streams, on many the decline of traffic is still under way. Whether the inland waterways of this country will ever be used to the same extent as the waterways of Europe is a question often discussed. Those who have been engaged in river transportation and have seen their business dwindle are naturally somewhat pessimistic about its

future. Many who have seen little or no response to the large sums spent by the Federal Government for the improvement of waterways are opposed to a continuation of what they contend is a wasteful expenditure of public funds. The opinion is often expressed here, as it was formerly abroad, that inland water transportation is obsolete, that the railways offer a cheaper and more convenient means of transportation. On the other hand, the vast majority of the people believe that the waterways can afford cheaper transportation and that as the country develops it will become increasingly necessary to utilize them to supplement the railways, whose capacity for handling traffic is not capable of unlimited expansion.

Many explanations have been given for the decline of water transportation in this country and the simultaneous growth of water transportation abroad. The lack of sufficient appropriations for waterway improvements as compared with the large sums spent by European countries is perhaps the one most frequently heard. Many are of the opinion that if the Federal Government would only prosecute the work of improving rivers more vigorously, they would soon regain their former importance as channels of commerce. But while such improvements are essential and will have their influence, a revival is not to be expected until the causes of the growth and decline of water transportation are better understood and a comprehensive policy based on this knowledge is adopted.

The main factors affecting water transportation may be divided into (1) natural conditions, by which is meant the existence or lack of natural waterways; (2) the improvements made, not only in the channels of streams but also in the construction of harbors equipped with all modern facilities, and in the organization and methods of water transportation so as to provide reliable service; (3) the abundance or dearth of supplies of raw materials, such as coal, lumber, iron ore, building materials, and grain accessible to the waterways, on the one hand, and the existence of large population to demand these products on the other; and (4) the relations existing between the railways and waterways, which include among other things the policy of the country in regulating these two methods of transportation, the system of railway rates in vogue, and the extent to which the railways and waterways cooperate or compete. There are also other factors, such as the habits and customs of different people and their methods of doing business, which are less fundamental.

The existence of favorable natural conditions varies with each country and with each waterway and constitutes an advantage which can only be partially overcome by the works of man. Likewise the existence of coal mines, quarries, forests, and other sources of coarse freights within reach of a waterway and the existence of large centers of consumption are conditions which vary greatly in different countries and for different streams within the same country. The methods and extent of making improvements and the policy regarding the relations between the railways and waterways are factors which depend directly upon the policy adopted.

The influence exerted by these four factors upon the development of water transportation in different countries forms the subject matter of the following chapters. A better understanding of their influence is necessary before a comprehensive policy regarding river and harbor improvements can be adopted.

II.

The Importance of Natural Conditions.

It hardly need be said that an essential requirement for the development of inland water transportation is that a country possess natural waterways, such as lakes, free rivers of good depth, or rivers which can be improved at a reasonable cost. Under modern conditions canals may be profitably utilized only in exceptional cases. Ship canals, such as the Suez or Panama, although of great cost, are of incalculable benefit to commerce because of the great saving in sailing distance which they effect. Ship canals are also useful in connecting inland cities with the seacoast where they are of comparatively short length and the elevation to be overcome is not too great. Good examples of this use are the Manchester Ship Canal in England, the canal from Ghent to Terneuzen in Belgium, and the North Sea Canal in Holland, which affords Amsterdam an outlet to the sea. The principal use of canals in an inland waterway system is to avoid rapids in rivers or to connect rivers and lakes so as to form through water routes. Where they are not too long and do not overcome too great elevations, canals may be successfully employed for such purposes, but ordinarily they are of too limited capacity and navigation in them is too slow and tedious to permit of their being extensively utilized as a means of transportation. Under modern conditions they can not be substituted at random for natural waterways.

The direction in which a river flows has an important influence upon the amount of traffic which it will secure. The streams on which the largest commerce has been developed invariably connect sources of supply with large centers of consumption. It is not difficult to recall instances where if rivers flowed in a different direction their traffic would undoubtedly be greatly increased. If, for instance, the Ohio River flowed into the Great Lakes or flowed east to some seaport, such as Philadelphia, it would have greater traffic possibilities. A good illustration is also furnished in Hungary, where, if the Theiss or Tisza, a tributary of the Danube, which traverses a fertile agricultural region, flowed west to meet the Danube near the large and populous cities of Vienna and Budapest, instead of south, it would undoubtedly have an enormous traffic in grain products which now are carried almost entirely by rail. In almost every country there are rivers whose direction of flow is unfavorable to the development of a large through traffic, although the local traffic may assume considerable proportions if the country adjacent is sufficiently populated.

It is not essential that a river should be of great depth, although this is an advantage. What is more essential is that its gradient should be gentle and its flow uniform, and also that a certain minimum depth should be maintained throughout the season of navigation. It is also important that a river should be free from silt; otherwise constant dredging is necessary to maintain the channel depth. Where rivers are not deep, the disadvantage can be offset to a considerable degree by the use of barges instead of larger boats. The cost of propulsion is very little increased by dividing a given tonnage among several barges instead of conveying it in one boat of

greater draft. The great variation in stream flow on some rivers materially affects their usefulness for navigation and makes difficult the installation of docks and terminal facilities. This has led in some instances to the use of storage reservoirs at the headwaters of streams for the equalization of stream flow.

The rôle played by favorable natural conditions in those European countries where the growth of water-borne traffic has been greatest has seldom been sufficiently emphasized. The view is sometimes held that almost every stream of any size if improved or any canal if constructed will convey a large traffic. The fact is that the growth of inland water transportation has been greatest in those countries which possess the best river systems combined with the most favorable natural conditions. It is also a noteworthy fact that in most countries the greater part of the inland waterway traffic is carried on a few large streams or canals possessing special advantages. In Germany, where water transportation has shown the greatest increase, 80 per cent of the inland waterway system, aggregating about 6,200 miles, is composed of rivers either free or canalized. Furthermore, it is an interesting fact that the five principal rivers—the Rhine, Weser, Elbe, Oder, and Vistula—flow in nearly parallel lines from southeast to northwest, forming water routes from the interior of Germany to the north Atlantic or Baltic seaports. Approximately four-fifths of the total water-borne commerce in Germany is carried on the first four of these river systems, only a small section of the Vistula, about 150 miles in length, being in Germany. As is shown by the following table, the Rhine system carries nearly half of the total tonnage:[1]

Waterway.	Receipts.	Shipments.	Total.	Per cent of total.
	Tons.	*Tons.*	*Tons.*	
Rhine system	31,217,934	27,172,134	58,390,068	49.28
Elbe system	8,138,466	9,242,178	17,380,644	14.68
Oder system	2,978,015	5,506,990	8,485,005	7.16
Weser-Ems system	3,878,855	4,084,129	7,962,984	6.82
Total, 4 rivers	46,213,270	46,005,401	92,218,701	77.94
Mark waterways	13,095,033	7,808,750	20,896,783	17.64
Eastern waterways	2,618,629	2,089,748	4,708,377	4.00
Danube waterways	379,462	290,125	669,587	.42
Total, all waterways	62,306,394	56,189,054	118,495,448	100.00

The total receipts and shipments in 1909 for the German Rhine without its tributaries aggregated 50,479,477 tons. Thus on 355 miles of river, or about one-twentieth of the total waterway mileage, more than 42 per cent of the total traffic was carried.

The Rhine is by far the most important river in Germany and carries a greater commerce than any other inland waterway in Europe. From the earliest times it has been an important route for commerce and trade to the interior of Europe. The Rhine is not a deep river, but its flow is relatively more uniform than that of most streams. This is due to the fact that the late melting of snow on the Alps maintains the stream flow during the dry seasons and also to the fact that the headwaters of the Rhine drain several lakes in Switz-

[1] Statistik des Deutschen Reichs, Band 235, I, 1909, Part I. p. X.

erland, the largest of which is Lake Constance. These lakes act as natural reservoirs to equalize the flow of the stream. Navigation is rarely ever impeded by low-water conditions and is usually possible for 300 days in a year. The direction of the Rhine's flow is very favorable to the development of large traffic, inasmuch as it affords a water route from the most densely populated and industrially developed section of Germany to the great seaports of Belgium and Holland, notably Amsterdam, Rotterdam, and Antwerp.

The gradient of the Rhine is, on the whole, very favorable for navigation. At Basle, where it crosses the German frontier from Switzerland, it is about 800 feet above sea level. The current is somewhat swift as far as Strassburg, a distance of 80 miles, when it becomes more gentle. From this point to Emmerich, on the Dutch frontier, there are only two places where the current is rapid. One is at St. Goar and the other at Bingen. The difficulty of getting upstream on these sections of the river has been obviated to a considerable extent by the use of powerful towing steamers. The following table shows the mean low-water depth of the Rhine and the gradient for different sections:[1]

Section.	Length in miles.	Depth at mean low water (feet).	Gradient (feet per mile).
Dutch frontier to Cologne	110	10.0	0.8
Cologne to St. Goar	82	8.2	1.1
St. Goar to Mannheim	79	6.6	.9
Mannheim to Strassburg	84	4.0	1.8
Strassburg to Basle	80	3.0	....

The Weser has very few of the natural advantages possessed by the Rhine. The average depth is from 3 to 5 feet, and the flow of the stream is much more irregular. In dry seasons navigation is frequently suspended because of low water. The gradient of the river is also much steeper than that of the Rhine. The principal advantage of the river is that possessed by the other German rivers, namely, that it affords a water route from the interior of Germany to the seaports of Bremen and Bremerhaven. The following table shows the depth and gradient of the Weser for different sections:[2]

Section.	Length in miles.	Depth at mean low water (feet).	Gradient (feet per mile).
Bremen to junction with the Aller at Eyssel	25	5-10	0.9
Eyssel to Minden	77	4.1	1.2
Minden to Carlshafen	98	3.3	2.0
Carlshafen to Münden	27	3.0	2.5

Next to the Rhine, the Elbe is the most important river in Europe. It is not so deep as the Rhine, and its flow is less uniform. In the lower reaches it has been somewhat difficult to improve because of the unstable character of the river bed. Frequently during dry

[1] Report of the Royal Commission on Inland Waterways and Canals, Vol. VI, p. 182. This volume contains the results of the foreign inquiry of the Commission. It was prepared by Mr. W. H. Lindley, and will hereafter be referred to as Lindley.

[2] Lindley, p. 182.

seasons navigation is impeded because of the low water. The principal natural advantage of the Elbe is that it affords water communication from Austria and the interior of Germany to the port of Hamburg, which is the most important seaport of the German Empire. The following table shows the depth and gradient of the Elbe for different sections:[1]

Section.	Length in miles.	Depth at mean low water (feet).	Gradient (feet per mile).
Hamburg to Geesthacht	24	6.0 -10.0	Tidal.
Geesthacht to Ihle Canal	147	4.1 - 4.6	0.8
Ihle Canal to Prussian-Saxon frontier	140	3.6	1.15
Prussian-Saxon frontier to Austrian frontier	75	4.25- 4.75	1.35

During the last few years Austria has canalized the Elbe from the German border to Melnik, and its tributary the Moldau from Melnik to Prague, to a depth of 6.5 feet.

The Oder possesses less natural advantages than the Elbe. It is not so deep and has been much more difficult to improve. In the upper reaches above Breslau it has been necessary to canalize the river in order to secure a sufficient depth. The principal advantage of the Oder is that it flows from the Bohemian frontier, through the center of Germany, to the port of Stettin. Both the Elbe and the Oder with their connections form water routes to the thickly populated district around Berlin. The Elbe flows on the west and the Oder on the east, and both rivers are connected with Berlin and with each other by means of several short waterways. The mean low-water depth of the Oder and the gradient by sections is shown in the following table:[1]

Section.	Length in miles.	Depth at mean low water (feet).	Gradient (feet per mile).
Stettin to Finow Canal	49	5.0-8.7	0.16
Finow Canal to Küstrin	31	4.25	.95
Küstrin to Breslau	223	3.0-3.3	1.5
Breslau to junction with Neisse	46	2.6-3.0	1.7

There are 895 miles of important canals in Germany and about 1,350 miles of other canals on which there is only a very small amount of traffic. The most successful canals form important links connecting the rivers; they are of comparatively short length and do not overcome great elevations. The best examples of this type are the canals in the Mark waterway system, which with the two canalized rivers, Havel and Spree, form connecting links between the Elbe and the Oder and the city of Berlin. The receipts and shipments on these waterways in 1909 amounted to more than 20,000,000 tons. Of this amount fully half was for Berlin and its suburbs. The lower Havel and the Ihle-Plauer Canal connect Berlin with the lower and upper Elbe, respectively, and the Finow and the Spree-Oder Canal afford connection with the lower and upper Oder. The

[1] Lindley, p. 182.

Finow Canal was begun in 1603, but not completed until 1746. It was enlarged during the years 1849–1860, and again during the years 1874–1885. It has a length of 64 miles and a depth of a little more than 5 feet. In spite of the fact that it accommodates boats of only 150 tons capacity, it carries an annual traffic of more than 1,000,000 tons. Because of its small capacity it is now being supplemented by a larger canal provided by the law of 1905, which will accommodate the regular 600-ton Oder barges. The Spree-Oder Canal in 1905 carried 2,256,000 tons.

The greatest canal achievement in Germany is undoubtedly the Dortmund-Ems Canal, completed in 1899. It extends from the Westphalian mining and industrial district to the port of Emden, and with its Herne branch has a length of 174 miles. It overcomes an elevation of 225 feet by means of 16 locks and one ship lift. It has a navigable depth of 6.6 feet and will accommodate barges of 600-tons capacity. The purpose of this canal was to divert the Rhine traffic from the Belgian and Dutch seaports to the German port of Emden. The canal traverses the heart of the great mining and industrial region of Westphalia, and it was confidently expected that it would carry 10,000,000 tons and that the tolls proposed would yield sufficient revenue to meet all maintenance charges and also to amortize the cost. Traffic on the canal in 1900, the first year of operation, was 476,000 tons, and in 1906, 1,731,000, an increase of 260 per cent, but far below the expected tonnage. It was found necessary in 1905, in order to encourage traffic, to reduce the tolls originally levied, so that the prospects of amortizing the cost of this project, which averaged about $105,000 per mile, are somewhat uncertain.

There are several other long canals in Germany which connect with the waterway system of other countries. The Main-Danube Canal connecting the two rivers indicated by its name is 110 miles in length, and overcomes an elevation of 880 feet by means of 100 locks. Its navigable depth is only 4.2 feet and the water supply on the summit level is not always ample. The Rhine-Rhone and the Rhine-Marne Canals connect with the French waterway system. The former is 87 miles in length, and overcomes an elevation of 700 feet by means of 90 locks. Its depth is only 4.6 feet. The latter canal is a part of a waterway to Paris. It is 65 miles long and about 6 feet deep, and employs 64 locks to overcome a height of 542 feet. There are also two tunnels, one of them more than a mile in length. These canals are of the older type and carry a relatively small traffic in comparison with the canals in the Mark waterway system. They can hardly be said to be profitable undertakings, in view of the large original cost and the heavy annual maintenance charges. A project is now being agitated to enlarge the Main-Danube Canal, at a cost of $67,500,000, to accommodate 600-ton barges. It is very doubtful if the capacity of this canal even if it should be enlarged could accommodate a traffic large enough to make it a profitable enterprise.

Holland is a country possessing unusual advantages for the development of water transportation. There are in all 560 miles of rivers and about 2,400 miles of canals in the Dutch waterway system. The most important rivers are the Rhine, with its two branches, the Yssel and the Waal, leading from Germany, and the Meuse, which connects with Liege and other interior cities of Belgium. The great artery of inland water traffic in Holland is the Rhine, which connects the Dutch and Belgian seaports with the inland cities of

Germany. In 1907 more than 17,000,000 tons of imports and exports were recorded as passing Lobith on the Dutch frontier, while the total receipts and shipments for the 110 miles in Holland are estimated at 23,028,224 tons.

Although the length of the canal system is much greater than that of the rivers mentioned, this is no disadvantage. Holland is a country particularly adapted for the construction of canals because of the low level land and the abundant water supply. Much of the land is below the level of the sea and also of the rivers, and few locks are required. For this reason canal building is far less costly and much more feasible than is usually the case.

Almost every town in Holland has water connections with the leading seaports. This explains why about 90 per cent of the traffic in Holland is carried on the inland waterways. The following table shows the growth of receipts and shipments by the inland waterways at Rotterdam. Almost 15,000,000 tons of this traffic is carried on the Rhine between Rotterdam and the German river ports. A small percentage is exchanged with Belgian cities and the remainder circulates through the Dutch waterway system.[1]

Year.	Number of vessels.	Metric tons.
1908	121,374	23,541,045
1907	123,507	24,573,332
1906	120,059	22,445,574
1905	114,222	20,731,957
1904	108,988	19,024,044
1903	106,144	17,785,342

Some idea of the amount of traffic which Amsterdam exchanges with the inland waterways is shown by the following table, which gives the traffic by years through the lock at Zeeburg on the Merewede Canal. The Rhine boats carry about one-sixth of this tonnage.[2]

Year.	Number of vessels.	Rhine boats.	Total tonnage.	Tonnage of Rhine boats.	Traffic with German Rhine ports.
1896	37,283	1,562	3,462,788	561,513	307,098
1900	44,155	1,900	4,737,320	919,228	444,475
1903	50,251	2,046	5,664,996	949,073	436,416
1904	50,477	2,096	5,922,357	944,100	428,859
1905	51,073	2,366	6,021,125	1,008,469	478,320
1906	54,415	2,176	6,523,713	1,006,446	538,945

The growth of water transportation has been marked in Belgium, but not as rapid as in Germany. One reason undoubtedly is that natural conditions are not so favorable. The rivers of Belgium are not so large as those of Germany. In fact, there are only two free rivers in the country—the Bas Escaut or Scheldt and its tributary, the Rupel, with a total length of 75 miles, and both of these are tidal. There are, however, a number of other rivers which, although small, have been capable of improvement at a reasonable cost. The most important of these are the Lys, the Dendre, Sambre, and Meuse.

[1] National Waterways Commission Document, No. 18, p. 52.
[2] "The Harbor of Amsterdam," report of the Chamber of Commerce and Industry, 1907, p. 80.

The direction of the flow of these Belgian rivers has been most favorable to the development of water transportation. The Lys, the Haut Escaut, the Dendre, the Dyle, and the Rupel Rivers all converge from the different parts of Belgium and northern France to form the maritime Scheldt, which has its outlet at Antwerp, while the Sambre and Meuse connect the eastern part of Belgium with the French waterways on the south and the Dutch waterways system on the the north. Thus most of the principal rivers focus at the one great seaport and on them is carried the larger part of the total waterborne commerce of the country. In 1907 the lower Scheldt alone, with a length of 67 miles or one-fifteenth of the total mileage, carried one-fifth of the total tonnage and one-fourth of the total ton-mileage of the whole waterway system.

The following table shows the total tonnage and ton-mileage on the seven principal rivers of Belgium for 1907. They comprise about one-third of the total waterway mileage, but carry more than half the total ton-mileage and nearly half of the total tonnage.[1]

Traffic on the principal rivers of Belgium.

Waterways.	Length (miles).	Total ton-mileage.	Total tonnage.
Escaut Maritime	67.5	296,376,272	10,089,911
Haut Escaut	59.2	89,250,966	1,943,078
Rupel	7.5	22,880,072	3,127,864
Lys	70.8	42,120,418	2,880,176
Dendre	41.0	27,166,287	1,296,299
Sambre	59.0	83,469,326	2,180,450
Meuse canalized	70.5	137,697,093	2,922,417
Total	375.5	698,960,434	24,440,195
Total, all waterways	1,023.7	1,198,295,230	52,249,129

The first five of these rivers belong to the Scheldt River system and focus at Antwerp. The Sambre and Meuse form a second route which connects the interior of Belgium with the Rhine and the Dutch seaports of Rotterdam and Amsterdam.

The canal system of Belgium is almost as long as the river system, but many of the canals are short connecting links and have been constructed through low, level country at relatively small expense. In this respect the eastern part of the country, bordering the seacoast, is much like Holland.

The following table shows the ton-mileage and total tonnage of the five principal canals in Belgium:[1]

Traffic on the principal canals of Belgium.

Waterways.	Length (miles).	Total ton-mileage.	Total tonnage.
Brussels to the Rupel	17.3	47,506,156	2,015,958
Charleroi to Brussels	45.5	36,068,925	1,087,083
Ghent to Ostende	43.5	63,158,241	2,988,810
Ghent-Terneuzen	11.0	14,560,526	1,302,761
Bois le Duc-Maestricht	29.5	87,693,944	2,288,701
Total	146.8	248,987,792	9,683,313
Total, all waterways	1,023.7	1,198,295,230	52,249,129

[1] Annuaire Statistique de la Belgique, 1908, p. 420.

Three of these canals, the first, third and fourth, are in reality ship canals. The canal connecting Brussels with the River Rupel has been deepened to 21 feet, the canal connecting Ghent with Ostende is 14 feet in depth, while the Ghent-Terneuzen Canal has a navigable depth of about 28 feet. The tonnage statistics given, however, do not include traffic carried by ocean-going vessels.

Considering its natural disadvantages, the canal from Brussels to Charleroi carries a surprisingly large traffic. It is 45.5 miles in length, and overcomes a height of 426 feet by means of 42 locks. The reason for its large tonnage is that this canal forms a direct route from the coal fields and industrial region of Charleroi to the port of Antwerp.

In the interior of Belgium there are a number of comparatively short canals which overcome considerable elevations. None of these have shown as rapid a growth of traffic as the waterways in the western part of the country. The Canal du Centre, which has only recently been completed, is 13 miles in length, and overcomes a height of 294 feet by means of 6 locks and 4 lifts. The cost of this waterway is estimated at more than $4,000,000. It certainly is a question whether the traffic on this canal will ever yield a fair return upon so great a cost. On several of the less important Belgian canals in the interior of the country the traffic has been stationary or has decreased during the last decade. Among these are the Ath-Blaton Canal, which has 21 locks for a distance of 13 miles; the Antoing-Pommeroeul Canal connecting the Escaut with the waterway from Condé to Mons, which has 13 locks for a length of 15.6 miles; and the Condé-Mons Canal, which has 5 locks in 12.5 miles.

France has sometimes been called the "Paradise of Canals," for it has more miles of artificial waterways than any other European country, and some of the canals carry a surprisingly large traffic. The total length of the waterways used for navigation in 1907 was 7,418 miles, of which 4,356 miles consisted of rivers and 3,062 miles of canals; but some of the rivers included in this mileage are very shallow and not capable of accommodating a large traffic. Some of the canals are also of little importance. The principal waterways of France comprise about 3,469 miles, half of which are canals. In 1907 these main lines, constituting less than half of the whole system, carried 85 per cent of the total traffic and 97 per cent of the total ton mileage.

While the inland-waterway traffic as a whole has shown a steady increase since the period of revival began, the absence of large free rivers and other natural disadvantages have made impossible such a rapid development as has taken place in Germany and Belgium. Although France has an area several times that of Belgium, and the length of her inland waterways is seven times the length of the Belgian system, the total water-borne traffic in 1905 was less than two-thirds that carried on the Belgian system. It was also about half the traffic carried on the German waterways, although in length the two systems are nearly equal.

The only free rivers in France are the Rhone, the Garonne, and the Loire. These three rivers are very shallow throughout most of their length. The Rhone has a depth of a little over 4 feet from Lyon to the Mediterranean Sea and a depth of only 2 feet above Lyon. The Garonne from Castets to Bordeaux has a navigable depth of 6 feet,

but is very shallow above Castets. The River Loire has been dredged so as to accommodate boats from the port of Nantes to St. Nazaire, a distance of 37 miles. Above this point the river is less navigable than formerly, owing to the large quantities of sand that have silted up its channels. Between Roanne and Briare the river is paralleled by a lateral canal 160 miles in length.

The steep gradient and great velocity of the current make the Rhone difficult to navigate, especially upstream. On the Garonne the gradient to be overcome is almost as great as that of the Rhone, while on the Loire the gradient is somewhat less. The average gradient for these three rivers is as follows:

	Feet per mile.
The Rhone	2.5
The Garonne	2.33
The Loire	2.10

The principal canalized rivers are the Seine, the Saône, the Yonne, and the Marne with their tributaries. In addition to these there are several rivers belonging to the Belgian system which rise in the northeastern part of France. These are the Lys, the Escaut and the Sambre.

The Seine, although canalized, is the most important waterway in France, and carried, in 1907, 9,300,000 tons, or more than 25 per cent of the total traffic transported on the inland-waterway system of the country. Its great natural advantage is that it connects Paris with the ports of Rouen and Havre.

Aside from the Seine, the rivers showing the largest traffic are given in the following table. It will be seen that all these rivers are in the northern part of France. They constitute sections of the main line from Paris to the principal coal fields of the country and to the Belgian frontier. The large traffic carried on these waterways, as will be explained in the following chapter, is due to exceptional conditions which outweigh the somewhat unfavorable natural conditions.[1]

Traffic on the principal rivers of France.

River.	Length in miles.	Total tonnage, 1907.	Total tonnage, 1910.
Oise, canalized	64.5	4,370,239	4,317,078
Escaut, from Cambrai to Étrun	7.5	5,567,147	5,783,626
Escaut, from Étrun to Condé	22.0	2,087,285	2,395,044
Scarpe, diversion around Douai	5.0	4,003,545	4,301,196
Aa	18.0	2,088,285	2,085,482
Lys	44.6	872,800	802,371
Sambre, canalized	33.5	825,287	787,724

The only river in France not included in the table above which has a traffic of more than 1,000,000 tons is the Marne, a tributary of the Seine, which joins it just east of the city limits of Paris. The traffic on this river and on the other principal rivers of France is shown by the table following.[1]

[1] Statistique de la Navigation Interieure, 1907 and 1910.

Traffic on the less important rivers.

River.	Length in miles.	Total tonnage, 1907.	Total tonnage, 1910.
Marne	113.5	1,015,042	1,041,578
Garonne, from Castets to the Dordogne	48.7	884,138	919,743
Saône, from St. Jean de Losne to Ile Barbe	125.3	825,928	955,569
Saône, from Ile Barbe to the Rhone	5.6	561,313	577,133
Rhone, Lyon to Arles	178.0	670,292	709,754
Rhone, Arles to the Mediterranean	30.0	412,653	402,045
Loire, from Nantes St. Nazaire	35.0	314,843	312,934

As will be seen, the traffic on these rivers is much less than on the rivers in the northern part of France, not because the natural conditions are any more unfavorable, but because the demand for transportation facilities is not so urgent.

While many of the canals of France carry but a comparatively small tonnage, there are some in the midland, eastern, and northeastern parts of France that carry a heavy traffic. There are 20 canals or sections of canals aggregating about 925 miles, each of which has an annual traffic of more than a million tons, and there are 6 other canals with a total length of 353 miles, with a traffic of more than half a million tons each. The large tonnage of these artificial waterways is due mainly to the fact that they are connecting links in important through routes. The Canal St. Quentin has the largest traffic of any of these canals. In 1910 it amounted to almost 7,000,000 tons, which is the maximum capacity of the canal. This waterway has a length of 58 miles and a depth of from 6 to 7.25 feet. Although of comparatively short length, it overcomes a height of 265 feet by means of 25 locks. It also has two tunnels, one of them of considerable length. This is perhaps the best example in Europe of an artificial waterway which, in spite of natural disadvantages, carries an enormous traffic. The reason is that it is a connecting link in a through route from Paris to the coal mines of northern France and to the Belgian frontier, between which localities there is a movement of traffic in heavy commodities far beyond what the railways can accommodate.

The limited capacity of the St. Quentin Canal, due to its unfavorable natural conditions, has retarded the rapid growth of traffic over this water route from Paris to the north. Consequently a plan for building a new canal to supplement this one has been adopted. Work on this new project known as the Canal du Nord was begun in 1905. The cost of construction is estimated at $11,580,000, and of maintenance and administration about $87,000 a year. It will be approximately 85 miles in length and about 7 feet in depth, and will have a total of 18 locks.

The following table gives the total tonnage and other information regarding the 10 canals carrying the largest traffic in France. All of these waterways are either in the northern or eastern part of the country. Considering the elevation that is overcome in several instances the traffic transported by these canals is unusually large and, as in the case of the rivers in this part of country, is due primarily to the great demand for transportation facilities.[1]

[1] Statistique de la Navigation Interieure, 1910.

Traffic on the principal canals.

River.	Length.	Navigable depth.	Elevation overcome (feet).	Number of locks.	Total tonnage in 1910.
St. Quentin	58.0	5.9	265.0	35	6,965,877
Lateral to the Oise	21.0	5.9	33.0	4	6,071,119
Haute-Deûle, from Fort-de-Scarpe to Bauvin	39.0	5.9	35.0	7	6,177,025
Sensée	15.5	5.9	16.0	1	4,585,420
Aire and branch	25.5	5.9	6.6	1	4,285,801
Marne to the Rhine and branch	128.0	5.9	978.0	113	3,904,550
Lateral to the Aisne	31.6	5.9	57.5	7	2,737,506
Lateral to the Marne	41.5	5.9	111.0	15	2,214,840
Oise to the Aisne	30.0	5.9	129.0	13	2,240,849
Aisne to the Marne	140.0	5.9	211.0	24	2,214,840

The remarkable showing made by these 10 artificial waterways, notwithstanding unfavorable conditions, indicates what the possibilities for water transportation would be if only a large free river such as the Rhine connected Paris with the northern coal fields and the Belgian frontier.

Russia has the largest waterway system of any country in the world. It comprises 3,158 rivers and their tributaries, 202 lakes, and 138 canals, aggregating more than 112,000 miles in length, but the traffic carried on the Russian waterways system is less than that on the Belgian system, with a total length of about 1,000 miles. Many of the Russian rivers are small and shallow and suited only for the rafting of lumber. The Volga system, with a length of 2,309 miles, or about one-fiftieth of the total, carries more than half the total tonnage of the whole waterway system, while the Neva system, about 633 miles in length, carries approximately one-seventh of the total traffic; and the Dnieper, 1,427 miles in length, carries about one-eighth. The traffic on the principal inland waterways of European Russia, not including Finland, Caucasus, and the Vistula region, in 1907 was as follows: [1]

	Tons.
Volga River system	18,930,645
Neva River system	5,822,580
Duena River system	1,972,580
Dnieper River system	4,248,387
Dvina River system	1,943,548
Niemen River system	1,906,451
Vistula River system	393,548
Other waterways	236,664
Total	35,454,403

The Austrian waterway system is composed almost entirely of rivers which aggregate in length about 4,000 miles, but of this navigable length 58 per cent is suitable for rafting only. About 900 miles can be navigated by small boats and 823 miles by steamboats. The total traffic on the inland waterways of Austria in 1905 amounted to 7,199,758 tons. All but about 200,000 tons of this amount was carried on the three principal rivers. The Elbe carried 3,969,669 tons; its tributary, the Moldau, 1,216,497 tons, and the Danube 1,869,911 tons. In other words, more than 95 per cent of the total water-borne traffic was carried on less than one-eighth of the waterway system.

The total length of the Hungarian waterway system is approximately 3,100 miles, of which 1,920 miles are adapted to steamboat

[1] National Waterways Commission Doc. No. 22, p. 53.

navigation and 1,180 miles to rafts and floats. The waterway system is composed almost entirely of the Danube and its branches. There is also one lake with a length of 75 miles, and four canals having a combined length of 219 miles. The total traffic on the Hungarian waterways for 1907 was 4,400,000 tons. Most of this traffic was carried on the Danube for the section near the large cities of Budapest and Vienna. On the other rivers in the system the commerce is not large.

One reason for the decline of water transportation in England is undoubtedly the dearth of large free rivers, such as are found in Germany. On the whole the natural conditions in England are very unfavorable for the development of water transportation. There are only a few small rivers suitable for navigation. To supply the deficiency a large number of canals were constructed in the early period, through a country whose topography is least suited for canal building. Many of these canals overcome considerable elevations within a comparatively short distance. As already stated, it was found necessary to employ flights of locks, lifts, and even tunnels to overcome the natural disadvantages. There are only 8 waterways which have a traffic amounting to more than 1,000,000 tons each. Although they aggregate 872 miles in length, or less than one-fifth of the total waterway mileage still in use for navigation, they carried in 1905 more than 19,000,000 tons, or half of the total water-borne tonnage.[1]

Waterway.	Mileage.	Tonnage[1] conveyed.	Ton miles.[2]
Birmingham Canal	159	7,546,453	....
Aire & Calder Navigation	85	2,810,988	59,591,231
Leeds & Liverpool Canal	145	2,467,827	48,395,651
Grand Junction Canal	189	1,794,233	41,629,468
Thames River, above London Bridge to Inglesham	144	1,395,642	23,300,000
Trent & Mersey Navigation	119	1,137,663	....
Regents Canal	11	1,045,184	....
Weaver Navigation	20	1,076,572	14,570,580
Total	872	19,274,562	....
Total, all waterways	5,085	39,498,926	....

[1] In England the long ton of 2,240 pounds is used.
[2] Ton-mile statistics are not collected on the railway-owned canals.

The Birmingham Canal has the largest traffic. In 1905 it was about three times that of any other waterway, and about one-fifth of the total water-borne tonnage of England and Wales. The reason for this enormous traffic on a shallow draft canal which can only accommodate boats of 30 tons capacity, is due to its location in the greatest mining and manufacturing center of England. Its sides are lined for miles with manufactories which were built there when the canal was the only means of transportation. Furthermore, this canal is now used as a feeder for the London and Northwestern Railway, which owns it. Most of its traffic is of a local nature; only a very small percentage leaves the summit level which this canal occupies, although it has connections with four different seaports. Hence its ton-mileage is small. The next important waterway is the Aire & Calder, which is composed mostly of small

[1] Report of the Royal Commission on Inland Waterways and Canals, Vol. VII, p. 53.

streams that have been canalized so as to afford slack water navigation. A large part of its traffic consists of coal, which is carried from Leeds to Goole on the Ouse for export. It has the largest ton-mileage of any waterway in the United Kingdom. The Leeds & Liverpool Canal is third in importance. Its traffic is also composed largely of coal carried from the collieries to manufacturing concerns located on its banks. Its ton-mileage ranks second. The large traffic carried on these few waterways shows what the possibilities might be were natural conditions more favorable. In all probability many of the English canals will eventually be abandoned because of the physical impossibility of modernizing them. The royal commission, in its report, recommended the purchase and improvement of only about 1,000 miles of waterways forming the principal routes from the Midlands to the seaports.

The United States undoubtedly possesses better natural waterways than any other country in the world. On the northern boundary there is the chain of lakes, which accommodates boats of 20 feet draft from Lake Superior or Lake Michigan as far as Buffalo on Lake Erie. According to the Report of the Commissioner of Corporations on Water Transportation, there are also 295 rivers capable of being used for navigation, with a total length of 26,400 miles. Five thousand eight hundred miles of river navigation have a depth of 6 feet or more for a greater part of the year. This includes 40 streams having a total length of 2,600 miles and a depth of nearly 10 feet.

The Mississippi River has a minimum depth of 30 feet from the Passes to the mouth of the Red River, a distance of 291 miles. From this point to Cairo, a distance of 750 miles, the mean low-water depth is 9 feet. From Cairo to St. Louis, a distance of 175 miles, 8 feet obtains for most of the year. Between St. Louis and St. Paul a depth of 4½ feet is generally available and a project for obtaining 6 feet is well under way. Were it not for the fact that the Mississippi from the mouth of the Missouri to the Gulf has an unstable bed with caving banks and shifting bottom, and that it is subject throughout its length to great variations in stream flow, it would excel even the Rhine in its natural advantages. With its tributaries it affords 2,500 miles of 6 feet navigation through the heart of the continent.

The Hudson is another river which possesses great natural advantages. For a considerable distance above its mouth it is tidal and has a depth of 25 feet. Throughout its length from New York City to Albany, a distance of 150 miles, it can accommodate vessels of 9 feet draft for most of the year, and an improvement is now being carried out which will result in a low water depth of 12 feet. The stream is not subject to great variations nor to the silting up characteristic of the Mississippi River system. With the Erie Canal it forms an important link in the water route from New York City to the Great Lakes. As far as natural advantages are concerned this river has not an equal in Europe.

It is evident that natural conditions have not been responsible for the decline of water-borne traffic in this country, although in particular cases they may have been a contributing cause. If favorable natural conditions were the only determining factor a large traffic should have developed on many of our streams as it has on the Great Lakes.

There are, of course, a large number of rivers in the country which are shallow or have currents too swift to be suited for any considerable commerce, even with extensive improvements. Some of our rivers are also not in the line of greatest traffic movement. This is especially true of the Tennessee, Kentucky and Cumberland Rivers, whose direction of flow and tortuous course are unfavorable to the development of a large through traffic. Since the Civil War the main line of traffic movement has been east and west or transversal to a number of large rivers, including the Mississippi.

From the foregoing it appears that only a few waterways in each country with exceptional advantages carry a large commerce. The movement of traffic is determined fundamentally by economic factors, and the most successful waterways are those which are in line with the greatest traffic movement. If such waterways are free rivers with physical characteristics favorable to their use for navigation, the expansion of their commerce is almost unlimited, while if they are small canalized rivers or canals, their ability to accommodate a growing traffic has decided limits. Where railway competition is involved the large free river is also better able to maintain its traffic because of the cheaper transportation which it affords.

III.

The Importance of Improvements.

The improvement of waterways is always necessary in order to make them serviceable for transportation, since no stream in its natural state is suitable for modern commerce. All have obstructions of various kinds, such as sand bars, rocky projections or rapids, which limit their navigability. Even lakes require the dredging of channels and the construction of harbors. Large free rivers with gentle slopes, as a rule, are much less expensive to improve than small streams with rapid current, the improvement of the latter being sometimes as costly as the construction of canals.

From the economic standpoint waterway improvements for aiding navigation are justified only when a sufficiently large traffic can be developed to yield a commensurate return upon the expenditures for this purpose. Hence, the waterways requiring the least improvement for a given traffic have the greatest advantage. The regularization or canalization of rivers and the construction of canals necessitate a much heavier expenditure than the simpler methods of river improvement, and generally speaking the more expensive the improvement the less the amount of traffic which can be accommodated. Thus it is not always feasible to undertake such improvements, even if the engineering difficulties to be overcome do not preclude their adoption.

The development of water transportation requires other improvements than merely deepening rivers and maintaining permanent channels. Whenever necessary and feasible the waterways of a country should be standardized and linked up so as to form through routes. Above all, channel improvements should be supplemented by ample harbors equipped with adequate terminal facilities. Physical connection with the railways should also be secured and such facilities should be under proper control so that the charges for their use may not be unreasonable. Improvements should also be made in the

type of vessel so that it may be adapted to the depth and width of a given channel, and in the means of propulsion or towage so that greater speed and cheaper motive power may be attained. The better organization of the water transportation business and the adoption of improved methods are also necessary in order to afford a more reliable service.

As a rule, in more advanced countries the improvement of rivers includes numerous objects not connected with navigation, such as the reclamation of overflowed lands, bank protection, the prevention of damage by floods, the development of water power as well as the maintenance and purification of the water supply. In making improvements to promote navigation one or more of these additional uses may also be developed. Where a stream is not destined to carry a large commerce it may prove of greater benefit in undertaking its improvement to make the promotion of navigation only a secondary purpose. In Hungary the improvement of rivers is largely under the supervision of the secretary of agriculture, the main purpose of their improvement being to reclaim valuable agricultural lands which are subject to overflow.

Where water-borne traffic has attained large proportions, the various improvements necessary for the promotion of navigation have been carried out. This fact has naturally led to the inference that the improvements were responsible in a large measure for the growth of traffic. As a matter of fact, improvements are more incidental than fundamental to the development of water transportation. Only where there is a large potential commerce will the deepening of channels and the use of improved methods and facilities for handling freight result in an immediate increase. The growth of traffic on a waterway does not necessarily keep pace with the number of dollars spent for its improvements but depends on more fundamental causes. It is not difficult to find cases, especially in the United States, where expensive improvements have been followed by a very slight increase or even a substantial decrease in traffic, and in foreign countries the results from an improvement in one case may be far different from the expenditure of a like amount on another project.

An erroneous impression is current in the United States that the main requirement for the revival of river commerce is increased appropriations for the improvement of channels. This is based on the belief that the remarkable growth of water transportation abroad has been due mainly to the large sums spent by those countries for improvements. The fact is overlooked that the United States has also spent large sums for the improvement of waterways, but with very different results.

While some of the earlier projects undertaken by European countries were adopted without careful investigation, the policy now is to examine with great care the traffic possibilities of each project before it is adopted. Furthermore, the State expenditures for channel improvements have been supplemented in many instances by local expenditures for the improvement of terminal facilities and by private expenditures for the better equipment and organization of the shipping business. The quick response of traffic to the improvements made is the usual result.

It is customary in most of the European countries to provide for the maintenance, administration, and operation of the waterways in the

annual budgets, while special laws or programs are passed when new works are to be undertaken. Up to March 1, 1907, the Prussian Government has expended for the improvement and maintenance of her rivers and canals, which include by far the larger part of the German waterway system, the following amounts:[1]

Waterway.	Improvements.	Maintenance.
Rhine River since 1816	$12,590,200	$5,712,000
Main River since 1876	2,213,400	642,600
Ems and Ems-Dortmund Canal	20,753,600	2,261,000
Weser, with the Fulda and Aller since 1842	3,165,400	2,094,400
Elbe since 1815	9,877,000	7,354,200
Brandenburg waterways up to Mar. 31, 1906	22,895,600	4,831,400
Oder since 1816	12,590,200	8,068,200
Vistula since 1831	23,942,800	11,590,600
Other waterways	17,207,400	9,329,600
Total	125,235,600	51,884,000

The other German States have also spent correspondingly large sums for the improvement of their waterways. The little State of Hamburg has made very large expenditures for the improvement of the Elbe in order to obtain a ship channel from the mouth of the river to the city. Hamburg is also spending more than $10,000,000 for the extension and improvement of its harbor. The State of Bremen has spent more than $8,000,000 for deepening the Weser from its mouth to the city, and is now spending $1,900,000 for the construction of a large storage reservoir at Hemelingen for the improvement of navigation. Bavaria has spent $3,665,000 for the improvement of the Rhine, $4,212,000 for the Main, and $5,426,000 for the Danube.

In Prussia and the other German States tolls are only charged on the canals and canalized rivers. There is a constitutional provision which prohibits the charging of tolls on free rivers. As a result the revenues derived from the tolls are not sufficient to defray the ordinary expenses of maintenance and administration of the waterway system, for, as already stated, nearly 80 per cent of the water-borne traffic in Germany is carried on the free rivers. The deficit which Prussia is obliged to pay each year averages about $4,000,000. Hence it is not surprising that during the last decade she has been very active in advocating a proposal to repeal this provision of the constitution. After granting large concessions to the various other States, a majority in favor of the proposition was finally obtained, and it passed the Reichstag in the latter part of 1911. But before tolls can be charged on the Rhine and Elbe it will also be necessary to obtain the consent of Holland and Austria, both of which countries are said to be unalterably opposed to such a policy.

The French Government has spent approximately $450,000,000 for the improvement and maintenance of its waterway system, as shown by the following table. This large expenditure has been made necessary because there are few large free rivers in France, and more than half of the waterway system is composed of canals. Furthermore the country is not naturally suited for canal construction. In most cases considerable elevations have to be overcome and reservoirs and

[1] Report of the consul at Hamburg to the National Waterways Commission in 1909.

pumping plants have to be installed in order to secure an adequate water supply.[1]

Period.	Rivers.	Canals.	Total.
Construction and improvement, 1814 to 1900	$128,439,471	$180,752,259	$309,191,730
Maintenance and repairs, 1814 to 1900	87,741,370	59,925,224	147,666,594

All tolls were abolished on the French waterways in the year 1880. Since this time expenditures for the maintenance and improvement of waterways have been met entirely by taxation. The present annual expenditure for this purpose is estimated at $2,000,000.

From 1831 to 1907, inclusive, Belgium spent on her waterways the following amounts.[2]

Maintenance, general improvements, and other current expenses	$25,777,000
New construction and other extraordinary expenses	81,118,000
Total	106,895,000

Belgium has always maintained tolls on all her waterways, with the exception of the two free rivers. Since 1831 these tolls have yielded the State a total revenue of $29,547,000, which is slightly more than the ordinary expense of maintaining the waterways during this period. In recent years, however, the tolls have not been sufficient to cover the entire cost of maintenance and other current expenses, and the deficit is paid by the Government. In 1905 it amounted to about $45,000.

Provinces, municipalities, and private interests have always voluntarily participated to some extent in waterway improvements, but during the last decade there has come about a movement especially in Germany and France, which makes it obligatory for the localities benefited by improvements to participate in the cost. In Prussia the law of April 1, 1905, adopted certain new works on condition that the Provinces and interested parties guarantee:

1. The cost of maintenance, working, and administration;
2. With certain alleviations, 3 per cent interest on about one-third of the capital; and
3. From the sixteenth year onward one-half per cent to the sinking fund, the State undertaking to find the money for the interest and sinking fund for the remaining two-thirds of the capital.

A change of policy in France was inaugurated by the law of 1903, which provides that for all new works the localities interested must contribute one-half of the expense and the Government will furnish the remainder. The localities however, are allowed to charge tolls, and in some cases to exploit towage monopolies, until they have reimbursed themselves. The tolls to be collected and the towage charges are fixed by the State. In carrying out projects already adopted, there is no requirement for the participation of localities, although their assistance is generally solicited by the Government before the work of improvement is undertaken.

No such principle has as yet been adopted in Belgium, but there is one notable instance of voluntary cooperation within the last decade. The 21-foot ship channel from the River Rupel to Brussels and the

[1] National Waterways Commission Document No. 16, p. 46.
[2] National Waterways Commission Doc. No. 20, p. 41.

inland harbor at Brussels were constructed by a corporation of communes. The State contributed during the years 1901–1908 $2,216,000 and the localities $3,146,000.

The different cities in Germany and Belgium have spent large sums on their river and canal ports. This has been especially the case on the three largest rivers in Germany. Some of the harbors have several basins, each intended for a particular use, and these river ports are equipped with coal tipples, electric cranes, and other devices for facilitating the rapid and economical loading and unloading of boats. In some cases their equipment is superior to that of any seaport of the United States. This is particularly true of the harbor at Duisburg-Ruhrort. The municipal supervision exercised over the docks and terminal facilities at these inland ports guarantees to shippers their use at reasonable rates. The city of Düsseldorf on the Rhine has spent $4,280,000 for enlarging and improving its harbor. The city of Cologne has spent on its two harbors $5,477,000 and $1,667,000, respectively. On the Oder the city of Breslau has expended $1,309,000 on its harbor. The city of Dortmund on the Dortmund-Ems Canal expended $1,963,500 for its harbor, the State of Prussia loaning the city $317,000 of this amount.

In Germany the different States have sometimes spent large sums for the construction of harbors. This has usually been done where the State owned the harbor or where it was intended to be an important transfer point between the State railways and the boat lines. Along the Rhine there are a number of State-owned harbors. The extent and equipment of these, as well as of the principal municipal harbors of the German Rhine from Strassburg down, are shown in the following statement:[1]

German Rhine ports.

Name.	Administration.	Loading space.	Cranes.	
			Number.	Capacity.
		Miles.		*Tons.*
Strassburg	Municipal	5.8	31	4
Kehl	State	6.4	10	8
Karlsruhe	Municipal	2.8	15	....
Rheinau	State	7.5	24	8
Mannheim	do	12.1	109	30
Ludwigshafen	do	3.4	57	10
Worms	Municipal	2.4	7	5
Gustavsburg	State	1.7	27	12
Mayence	Municipal	4.0	16	5
Bingen	do	.9	5	7
Coblenz	State	.7	4	9
Cologne	Municipal	5.2	45	30
Mülheim on the Rhine	do	.62	10	6
Düsseldorf	do	6.2	36	25
Duisburg-Ruhrort	State	12.7	84	30
Emmerich	do	1.9	10	5
On the Main:				
Frankfort	Municipal	3.2	38	8
Offenbach	do	.9	7	10

The State of Baden spent during the years 1865–1902 over $5,000,000 for the transfer harbor and terminal facilities at Mannheim and in order to encourage the growth of traffic at this port has maintained the harbor free of all dues. The city itself also spent $1,850,000 for an industrial harbor. The total expenditure of the

[1] National Waterways Commission Doc. No. 19, p. 57.

different States along the Rhine for their river ports amounts to nearly $25,000,000.

Some of the principal cities in Belgium have also spent large sums on their inland harbors. This is especially the case at Brussels, Bruges, and Ghent. In France the only three river ports of any importance are at Rouen and Paris on the Seine, and at Roanne on the Loire. The extent and the equipment of these three river ports is hardly comparable with that found in Germany. The commerce is much smaller and the predominance of canals makes such elaborate equipment less necessary.

The large expenditures for waterway improvements by States and localities in Europe have generally resulted in a substantial increase in commerce, because the potential traffic was there before the improvements were undertaken. In some cases the returns have been much greater than in others, for almost all the European countries, in their enthusiasm for water transportation, have adopted projects which have not yielded benefits in proportion to those usually obtained from such investments. It is a noticeable fact, however, that expenditures by localities for inland harbors have rarely ever been made except where a large prospective traffic existed.

On the whole, waterway improvements in Germany have been followed by a more rapid growth of traffic than in other countries. When the Main was canalized from the Rhine to Frankfort, at a cost of $2,200,000, the traffic increased from 250,000 tons in 1887, the first year of operation, to 3,270,668 tons in 1909. During this period the receipts and shipments at Frankfort increased from 156,000 to 1,600,000 tons. When the Spree-Oder Canal was constructed to connect the upper Oder with Berlin and the lower Elbe the traffic increased from 637,000 tons in 1891, the first year of operation, to 2,256,000 tons in 1905. The upper Oder above Breslau was canalized in 1896, and traffic increased from 288,000 tons to 1,730,000 tons within 10 years. The enlargement of harbors, especially along the Rhine, has in almost every instance been followed by a large increase in traffic. The most noticeable increases have occurred at Mannheim and at Duisburg-Ruhrort. In the former case the receipts and shipments increased from 1,415,279 tons in 1885 to 4,922,465 tons in 1900 and to nearly 6,000,000 tons in 1909. In 1900 the total receipts and shipments at Duisburg-Ruhrort amounted to slightly more than 14,000,000 tons. In 1909 they had increased to nearly 20,000,000 tons.

The best examples in France of a large increase in traffic following improvements are found on the Seine. On the section from Paris to Rouen about $12,500,000 have been spent to obtain a reliable depth of 10 feet. As a result, the traffic has increased more than 75 per cent since 1895. At Paris the total water-borne traffic has increased from 4,749,000 tons in 1885 to more than 10,000,000 tons in 1910.

In the United States the expenditures for river and harbor improvements has been much larger than is generally realized. Since 1802 the Federal Government has appropriated about $366,000,000 for the improvement of rivers, $240,000,000 for harbors, and $40,000,000 for canals. In addition there have been appropriated about $10,000,000 for examinations, surveys, and other miscellaneous items, making the total appropriations for all improvements, up to and including the

river and harbor bill of February, 1911, fully $650,000,000.[1] About $25,000,000 of this amount appropriated has not yet been spent. The aggregate expenditures of the Government to the close of the fiscal year ending June 30, 1911, according to a recent report of the Secretary of the Treasury, amount to $627,098,236.05.[2]

It may be said without contradiction that the United States has derived less benefit from the expenditures of these large sums for waterway improvements than any of the European countries have from theirs. This is due partly to the lack of a comprehensive policy and partly to the fact that the improvements of rivers are not fundamental to the growth of traffic. Economic factors are more important. The Government has expended $121,142,554 upon the Mississippi River, and since 1885 the traffic has been steadily declining. During the last few years the Mississippi has had a depth of 30 feet from New Orleans to Memphis, 9 feet from Memphis to Cairo, 8 feet from Cairo to St. Louis, and 4½ feet from St. Louis to St. Paul; but the present traffic is not more than a third of what it was in 1880, when the channel depth for these different sections of the river was much less. A good index of the decline of traffic on the upper Mississippi River is shown by the statistics of shipments from St. Louis. In 1880 shipments by steam boats and barges amounted to 1,038,350 tons. At this time the depth of the river was only 3½ to 4 feet. In 1900 the shipments had declined to 601,862 tons. In 1903 thay had fallen to 212,207 tons; and in 1904 to 82,565 tons. In 1910 they had decreased to 48,425 tons, while the depth of the river had increased to 8 feet for most of the year.

During the period 1880 to 1910 the total receipts and shipments at St. Louis decreased almost 90 per cent, as shown by the following table:[3]

Year.	Shipments.	Receipts.	Total.
1880	1,038,350	1,092,175	2,130,525
1890	601,862	663,730	1,265,592
1895	303,355	508,830	812,185
1900	245,580	512,010	757,590
1905	80,575	289,850	370,425
1910	48,425	143,540	191,965

The receipts and shipments at St. Louis via the upper Mississippi River have declined from 1,314,379 tons in 1880 to 43,090 tons in 1910.[4]

On the Missouri River up to and including June 30, 1911, $11,425,000 have been spent for improving the channel, and yet on the stretch between the mouth and Kansas City in 1910 only 41,502 tons of freight were carried if the sand and gravel hauled for a distance of less than a mile at Kansas City is excluded.

There are many instances in the United States where the expenditures by the Federal Government have far exceeded the demand for transportation facilities. On a considerable number of the streams the Government has built expensive locks and dams where the traffic consists mostly of saw logs, railroad ties, and other lumber products

[1] Senate Doc. No. 807, 61st Cong., 3d sess.
[2] Senate Doc. No. 382, 62d Cong., 2d sess.
[3] Report of the Commissioner of Corporations on Transportation by Water, Part II, p. 295. The figures for 1880 are from the Annual Report of the Chief of Engineers, 1901, Supplement, p. 38, and those for 1910 are obtained from the St. Louis Merchants' Exchange.
[4] Annual Report of the Chief of Engineers, 1911, p. 1934.

which are generally rafted and do not require such expensive improvements. As soon as the forests are exhausted the traffic will be greatly reduced. A few examples are shown by the following table:[1]

River.	Expenditures.	Total traffic in 1910.	Lumber products.
		Tons.	*Tons.*
Big Sandy	$171,812	185,534	184,572
Kentucky	3,623,271	254,721	144,978
Ouachita	1,834,719	57,684	28,880
Trinity	867,714	73,789	62,102
White, Arkansas	457,019	118,496	109,145
Upper White	813,166	27,403	5,042

A striking example of large expenditures with little return is found on the Red River in Louisiana. Up to June 30, 1911, the Government had expended for the improvement of this river $1,457,499. The traffic on this stream for the calendar year 1910 was 48,702 tons, of which 48,640 tons were composed of lumber products capable of being rafted. A still more striking example of the extravagant expenditure of money by the Federal Government for waterways is the Illinois & Mississippi Canal, generally known as the Hennepin Canal. For the construction of this artificial waterway the Federal Government expended $7,463,680. The traffic on the Milan section of this canal for the fiscal year 1911 amounted to 5,115 tons, while traffic on the eastern and western sections for the calendar year 1910 amounted to 244,635 tons; but this figure is obtained by adding together the tonnage statistics collected at each one of the 37 locks, and hence is misleading. If all duplications were eliminated it is probable that 25,000 tons would cover the actual traffic on this division of the canal.

The annual reports of Army engineers for rivers under their supervision furnish many illustrations of the lack of response to improvements and every year numerous recommendations are made that the further improvement of such streams be discontinued. On the Minnesota River, for instance, the Government has already spent $146,179. The engineer in charge makes the following report:[2]

> As will be seen on the graphical record for this river, there has never been any commerce, whereas considerable sums of money have been expended. Although a practicable channel has been provided at the mouth of the river, it has never been used except by pleasure boats, and there is no prospect that it will be. For this reason I recommend that the annual expenditure for maintenance of this channel be discontinued, as it is not warranted by any existing or prospective commerce.

On the Tombigbee River above Columbus the Government has carried on the work of improvement since 1872. The total appropriations amount to $90,667. In 1910 an examination of the stream was made, and it was recommended that the section between Aberdeen and Walker's bridge be abandoned.[3]

On the other hand, some of the improvements carried on by the Federal Government have been followed by a large increase in traffic. This is especially true of those channels which afford an entrance to the important seaports on the Atlantic, Gulf, and Pacific coasts. It is also true of several of the Great Lake ports, especially Duluth

[1] The expenditures are taken from S. Doc. 382, Sixty-second Congress, second session, and the traffic statistics from the Annual Report of the Chief of Engineers, 1911.
[2] Annual Report, Chief of Engineers, 1911, Vol. II, p. 1981.
[3] Annual Report, Chief of Engineers, 1911, Vol. II, p. 1710.

and Superior. Perhaps the best instance of the rapid increase of traffic following improvements is found in the various channels connecting the Great Lakes, such as the St. Marys River, the St. Clair Flats Canal, and the Detroit River. Every additional inch of depth has been utilized. The capacity of boats has been constantly increasing, and the cost of transporting the enormous iron ore and coal traffic has steadily declined. On these channels the Government has spent the following amounts:

St. Marys River and Canal	$9,289,874
Hay Lake and Neebish Channels	17,607,523
St. Clair River and St. Clair Flats Canal	1,013,135
Detroit River	9,700,283

During the last three decades the traffic passing through these channels has increased 2,000 per cent. In 1910 it amounted to more than 60,000,000 tons.

There are several reasons why the expenditures for waterway improvements in the United States have so often been followed by such disappointing results. Among these, however, should not be included the skill and character of the engineering work. The methods of improving rivers to promote navigation in this country are on the whole as advanced, from the engineering standpoint, as those employed in Europe. In fact there is little difference in methods, except in details and in the extent to which they have been carried out. Practically all the different types of dams used in river improvement in Europe can be found in different parts of the United States. The type of locks used is also much the same. Boat lifts have been more frequently tried in Europe than in the United States, but they have not proved entirely satisfactory.[1] As difficult engineering works have been performed in connection with river and harbor improvements in this country as have been witnessed abroad.

A minor reason is the lack of coordination found in the administration of waterway improvements. Such administration is much more complete in France, Belgium, and Germany than in the United States. In France the rivers and canals are supervised by the administration des Ponts et Chaussees, which is directly under the Minister of Public Works. The improvements are carried on according to a comprehensive plan adopted in 1879, which has resulted in the standardization of the principal lines throughout the country to a navigable depth of 5.9 feet. The Seine with a depth of 10 feet is the only exception. In Belgium the administration of rivers and canals resembles very much that of France, after which it was modeled. The waterways have been improved and standardized so as to accommodate 300-ton barges. There are only three ship canals with a greater depth. In Prussia there is a special department under the minister of public works which supervises the improvement of the State-owned waterways, but for the large rivers special boards have been created. Such boards have been established for the Rhine, the Elbe, Oder, Weser, Vistula, and also for the Ems and Dortmund-Ems Canal. In the United States river and harbor improvements have been carried on by the Corps of Engineers, under the direction of the Secretary of War. The country is divided into

[1] An excellent comparison of methods used here and abroad for the improvement of rivers is given by Brig. Gen. W. H. Bixby, Chief of Engineers, in the Preliminary Report of the National Waterways Commission, page 63.

districts, each of which is in charge of an officer. Owing to the lack of a definite policy, the improvements are carried on in each district and for each river or section of river with little regard to what is being done elsewhere. No attempt has been made to standardize the river systems and the tributaries are often deeper than the main streams. The only instance where the improvement of a river is carried on as a whole is the Mississippi River. In 1879 a special board was created similar to those in charge of the principal rivers in Germany. This commission has complete supervision over the improvements of the Mississippi River from St. Louis to the Passes.

An important reason for the failure of appropriations to result in a growth of traffic is that until recently the purpose of improving waterways has not been an earnest desire to use them as an agency of transportation. Other purposes of a political or local nature or the desire to force down railroad rates have often predominated. Hence the real traffic possibilities of projects have been little considered, and with the 295 navigable streams and 200 harbors requiring improvement there has been a disposition to distribute river and harbor appropriations over a large number of projects instead of concentrating them upon those which expert investigation showed to be worthy of undertaking. In view of the careful investigations of the traffic possibilities of projects before their adoption by European countries, it is a most surprising thing that until the year 1899 it was customary in this country to adopt projects without any investigation whatever of their traffic possibilities. The engineers were authorized by law simply to submit to Congress an estimate of the cost of improvement, and the probable benefits of the improvement were left to the imagination of the legislators. Thus projects of all kinds were adopted and their improvement for navigation undertaken without regard to their future possibilities. Nor as a rule was any other purpose than the promotion of navigation considered, although this might be the least important use of a stream.

It has been generally realized that much of the money appropriated for the improvement of rivers was wasted, and efforts have frequently been made by those who were desirous of securing greater economy in Government expenditures to prevent the frequent enactment of such bills. In at least one instance a rivers and harbors bill was defeated for purely political reasons by a filibuster deliberately planned for that purpose. Consequently appropriations for river and harbor improvements have until recently been intermittent and irregular instead of being carried on in a businesslike manner, as would have been the case if the purpose of the appropriation had really been to promote navigation.

As has often been pointed out, the worst feature of spreading river and harbor appropriations over a large number of projects in order to insure the passage of such bills is the impossibility of spending enough on any one project to complete it promptly and economically. Oftentimes the improvements have been continued over a long period of years, and much of the work done under one appropriation has deteriorated before another appropriation was obtained. Thus the total cost of completing a project is greatly enhanced and its utilization for navigation delayed. The engineers in charge of different improvements state each year what amount they will need to carry on the work most efficiently and economically, but they are often given only a very small percentage of the required amount.

A gradual improvement in making appropriations has come about during the last 10 or 12 years. Engineers are now required by law to base their recommendations for the adoption of projects upon the traffic possibilities of projects as well as upon the cost of construction. By the river and harbor act of 1902 a board of review was created, whose duty it is to pass upon the merits of each project. The Chief of Engineers is also required to do the same and the rule has been generally followed since that time of adopting only those projects which have received the favorable recommendation of both the board of review and the Chief of Engineers. In 1910 the plan of having annual river and harbor bills was also adopted, which should bring about more continuous work on projects under way. While the traffic possibilities of streams are not as carefully investigated as is the case in Europe, and occasionally projects are recommended which prove to be very disappointing in their results, yet an important step forward has been made, which in time will undoubtedly result in placing the river and harbor appropriations upon a more businesslike basis.

Another reason for the failure of river and harbor appropriations to show results is that the minor political subdivisions as a rule have made little or no attempt to supplement Federal expenditures for channels with local expenditures for terminals. Furthermore, as pointed out by the Commissioner of Corporations in his report on water terminals, most of the available water frontage not only at the seaports but also on the Great Lakes and along the principal rivers is owned by private interests, prominent among which are the railroad companies. The localities, as a rule, do not attempt to regulate the use of private docks and terminals, nor have they provided public docks for the use of water carriers. Out of more than 50 important ports in the United States there are only two, New Orleans and San Francisco, which have a public control at all comparable with the supervision exercised at most of the European ports.

The indifference of local authorities to the development and control of their terminal facilities largely nullifies the benefits that might result from the appropriations by the Federal Government for channel improvements, and the control which the railways have obtained over desirable water frontage has been very detrimental to the growth of water transportation. At Buffalo, Philadelphia and other ports the railways often refuse the use of their docks to independent boat lines or allow such use only on condition that the freight unloaded on them shall be sent over their lines. Where they own boat lines, as on the Great Lakes and in the coastwise trade, their control over terminal facilities is a most important factor in eliminating the competition of independent lines.

While the lack of civic enterprise may be responsible in some cases for the inadequate development and control of terminal facilities in this country, the real cause in most instances is that the communities realize that such expenditures would not be profitable investments.

Improvements can not increase the movement of traffic by water unless for economic reasons it potentially exists. Private or local interests are less willing than the Federal Government to make expenditures for improvements unless the results are such as to warrant them. But the failure on their part to provide adequate terminals properly controlled furthers the decline or retards the growth of water transportation. The result is what has sometimes

been very properly termed a vicious circle from which it is difficult to escape.

IV.

THE IMPORTANCE OF ECONOMIC FACTORS.

The rapid development of water transportation which has taken place in Europe and elsewhere has been due to something more than good lakes or rivers and modern improvements. Economic causes, which determine the movement of traffic from one place to another have been more potent. Transportation on an inland waterway will be large only where there exists accessible to it an abundance of those commodities which are naturally suited to be transported by water, and also thickly populated or industrially developed localities along its banks or within reach, which demand these commodities in large quantities. There is no instance of a waterway carrying a large traffic where such conditions do not exist. Before the advent of railway construction, when the waterways enjoyed a practical monopoly of transportation, they carried all classes of commodities and even passengers, but as railway competition increased their business became more and more confined to certain classes of coarse, bulky freights. If these were not available and in demand to take the place of the higher classes of freight the traffic of the waterways necessarily declined. Where cooperation between the railways and waterways exists for the transfer of freight the area which the latter can reach is much enlarged, but where such cooperation does not exist the business of a waterway is necessarily confined to its banks. Under such circumstances the only successful waterways are those which afford a direct route between coal mines or other sources of supply of coarse bulky freight and centers of consumption.

The importance of these economic factors in the development of water transportation are well illustrated by the principal waterways in Europe. Here we find thickly settled districts which require much larger quantities of food supplies and other raw products than they are capable of producing. Hence these commodities must be imported, and an important source of business for European waterways has been the distribution of this import traffic from the seaports to the interior cities. The principal domestic sources of traffic have been coal, building stone, sand and gravel, lumber, grain, and other coarse bulky freight. These few commodities form the bulk of traffic on all the principal waterways.

In 1909 the total traffic of the German waterways amounted to 75,115,272 tons, divided into the following amounts:[1]

	Tons.	Per cent.
Coal	21,221,606	28.2
Lignite	1,227,295	1.6
Dirt, sand, pyrites, marl	8,999,881	12.0
Iron ore, except pyrites	6,741,825	9.0
Lumber and wood of all kinds, except basket willow	6,149,452	8.2
Brick and tiles	5,457,074	7.3
Grain of all kinds	5,120,855	6.8
Ores (other than iron) and slag	1,724,007	2.3
Building stones	1,648,000	2.2
Cement and cement products	1,069,402	1.4
Heavy iron products	1,192,144	1.6
All others	14,563,731	19.4
Total	75,115,272	100.0

[1] Statistik des Deutschen Reichs, Band 235, I, 1909, Part II, p. VIII. This figure is about 2,000,000 tons larger than the figure given on page 481.

Some of these commodities are imported and some are obtained from domestic sources. In the former class are English coal, lignite, iron ore, and grain. In the latter, German coal, dirt, sand, gravel, brick and tiles, and heavy iron products. Coal and lignite both imported and domestic form almost 30% of the total tonnage.

As already suggested, the rapid growth of traffic on the German rivers has been due partly to the fact that they afford water routes from the seaports to the populous interior, and thus make possible the cheap importation of raw products which the interior cities demand. The Rhine affords a water route from the Belgian and Dutch seaports to the very thickly populated districts of western Germany, where the density averages more than 600 persons per square mile. Almost twice as much freight is imported and exported as is local. In 1907 the exports and imports passing the Dutch frontier amounted to 23,080,000 tons, while the local commerce of the river—that exchanged between the different German ports—was only 12,400,000 tons. In 1909 the imports amounted to 14,881,299 tons and the exports to 9,964,662 tons. All but about 3,000,000 tons of this import and export traffic is handled at Rotterdam, Amsterdam, and Antwerp. The receipts and shipments by the Rhine at each of these ports in 1907 is shown by the following table:[1]

Ports.	Receipts by river.	Shipments by river.	Total.
	Tons.	*Tons.*	*Tons.*
Rotterdam	2,085,989	12,674,637	14,760,626
Amsterdam	275,281	306,905	582,186
Antwerp	2,691,241	2,246,495	4,937,736
Total	5,052,511	15,228,037	20,280,548

The import traffic on the German Rhine is composed largely of iron ore, grain, English coal, lumber of various kinds, and other ores. The amounts imported from Rotterdam, Amsterdam, and Antwerp, respectively, are as follows:

Port.	Total.	Iron ore.	Grain.	English coal.	Wood.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Rotterdam	12,674,637	5,384,461	2,225,811	1,742,372	1,100,697
Amsterdam	306,905			39,764	
Antwerp	2,246,495	348,495	782,415		

The export traffic from the German Rhine ports is composed principally of coal, sand, gravel, and manufactured iron products. The amount of these exports received at the three seaports in 1907 is as follows:

Ports.	Total.	German coal.	Sand, gravel, etc.	Manufactured iron.	Cement, limestone.	Fertilizers.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Rotterdam	2,085,989	766,227	300,422	266,329	95,390	76,911
Amsterdam	275,281	26,035	50,896	69,820	31,233	
Antwerp	2,691,241	1,660,492	238,668	369,311	94,383	43,870

[1] Clapp, The Navigable Rhine, p. 74–75.

The amount of traffic imported by different Rhine cities from foreign countries in 1909 is shown by the following table:[1]

Receipts of foreign commerce at Rhine ports.

Port.	Traffic.	Port.	Traffic.
	Tons.		*Tons.*
Duisburg-Ruhrort	3,657,170	Worms	152,576
Düsseldorf	613,018	Ludwigshafen	777,526
Neuss	353,635	Mannheim	2,151,982
Cologne	398,862	Rheinau	205,361
Mainz	222,483	Karlsruhe	162,687
Gustavsburg	121,744	Strassburg	329,636

At Duisburg-Ruhrort 2,015,600 tons of iron ore alone were imported. This freight came mostly from Rotterdam. At the combined harbors of Mannheim, Ludwigshafen, and Rheinau the amount of wheat and other cereals imported was considerably more than 1,000,000 tons, while English coal amounted to 455,000 tons.

The principal domestic commodity transported on the Rhine is coal obtained from the mines of the Ruhr district. This is brought by rail to river port of Duisburg-Ruhrort and transshipped to river boats. The traffic at this port is growing more rapidly than at any other in Germany. Already it constitutes more than one-third of the total receipts and shipments of all the important Rhine harbors, which in 1909 amounted to 45,781,000 tons, and is even larger than the foreign commerce of the port of Hamburg. The shipments from Duisburg-Ruhrort in 1909 amounted to 14,018,678 tons, of which 12,352,631, or 90 per cent, consisted of coal. Of this amount, 5,871,717 tons were exported and the remainder shipped to the other Rhine ports in Germany.

At Duisburg-Ruhrort the shipments are 3½ times the receipts, while at the remaining Rhine ports the receipts exceed the shipments, and the commodity received in largest quantities is coal. At Mannheim coal amounts to almost 40 per cent of the total receipts, and at Ludwigshafen and Rheinau about 90 per cent. The following table shows the shipments from Duisburg-Ruhrort upstream to several of the other Rhine ports. This traffic consists almost wholly of coal and a small amount of coke:[1]

Shipments from Duisburg-Ruhrort.

To—	Tons.	To—	Tons.
Gustavsburg	907,484	Karlsruhe	260,732
Ludwigshafen	662,581	Lauterburg	328,141
Mannheim	1,641,091	Strassburg	402,728
Rheinau	1,072,983		

The export and import traffic on the Elbe, Oder, and Weser also constitutes an important part of their commerce. The Elbe and Oder are connected with the populous district of Berlin. This city and its suburbs have a population of more than 3,500,000, and are dependent to a considerable extent for their supplies of coal, grain

[1] Statistik des Deutschen Reichs, Band 235, I, 1909, Part I, p. XV.

and other food products and building materials on the cheap transportation afforded by these rivers from the seaports of Hamburg, Lübeck, and Stettin. More than 90 per cent of the water traffic in the district of Berlin consists of receipts and less than 10 per cent of shipments, which shows the importance of this district as a great consuming center. There are also several important cities on the Elbe, such as Magdeburg and Dresden, which exchange large quantities of traffic with Hamburg. On the Oder the largest city is Breslau. It exchanges traffic with both Stettin and Hamburg.

The receipts and shipments from Hamburg to and from the interior by water are shown by the following table:[1]

Goods shipped from Hamburg to the interior by water.

	Food products.	Building material and fuel.	Raw products and semimanufactures.	Dry goods and fancy articles.	Products of art and industries.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1899	1,164,299	618,283	1,679,596	6,580	45,370	3,514,108
1900	1,074,893	763,396	1,560,558	5,764	52,603	3,457,214
1901	1,397,165	574,532	1,457,034	6,546	54,664	3,489,941
1902	1,227,662	619,386	1,431,153	8,259	49,424	3,335,884
1903	1,272,908	739,812	1,729,335	7,264	50,446	3,799,768
1904	954,756	561,282	1,456,035	4,098	36,845	3,013,016
1905	1,571,146	1,038,809	1,964,558	6,732	62,220	4,643,465
1906	1,509,215	1,263,463	2,171,542	4,347	59,417	5,007,984
1907	1,609,448	1,811,191	2,347,708	7,727	68,069	5,844,143
1908	1,263,246	1,994,136	2,193,764	7,876	63,702	5,522,724

Goods arrived in Hamburg from the interior by water.

	Food products.	Building material and fuel.	Raw products and semimanufactures.	Dry goods and fancy articles.	Products of art and industries.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1899	1,185,613	617,360	506,380	1,729	124,358	2,435,440
1900	1,312,343	557,542	596,443	1,529	139,063	2,606,920
1901	1,267,254	525,099	653,011	1,277	118,965	2,565,606
1902	1,141,423	587,681	588,237	1,807	130,265	2,449,413
1903	1,612,161	730,936	707,407	2,712	173,770	3,226,987
1904	979,620	541,157	532,603	2,294	122,382	2,178,056
1905	1,057,611	832,296	925,036	4,686	181,543	3,001,172
1906	1,498,088	969,961	905,350	5,013	189,385	3,567,797
1907	1,258,872	912,605	813,900	4,924	196,507	3,186,808
1908	1,241,793	907,232	755,401	3,980	174,370	3,082,776

The largest single item shipped from Hamburg by river in 1909 was English coal, amounting to 2,496,980 tons; the next in importance was grain, amounting to 1,390,605 tons. Sugar forms the largest item of receipts, amounting in 1909 to 1,001,198 tons.

It is difficult to ascertain the exact amount of traffic which Berlin and other interior cities import from Hamburg on the Elbe and Stettin on the Oder, inasmuch as practically all the imports are transshipped by ocean-going vessels to river boats and barges, and for this reason are registered in the tonnage statistics as domestic traffic. In 1909 the three traffic districts including Berlin and the localities along the Mark waterways received from the traffic district of Hamburg

[1] National Waterways Commission Doc. No. 19, p. 82.

2,352,081 tons, of which 1,696,000 tons consisted of coal and 59,777 tons of coke. Practically all of this coal and coke came from England. Two hundred and twelve thousand tons consisted of grain of various kinds and flour. A considerable quantity of tar, pitch, resin, and other naval stores was imported and also oils, fats, and lards.

In 1909 the same three traffic districts imported 801,441 tons from the port of Stettin. The largest items were coal, amounting to 294,615 tons, and wood of all kinds, amounting to 106,119 tons. A small amount of grain, building materials, and various other commodities were also included. As in the case of Hamburg, practically all the coal came from England.

There are no coal mines accessible to the Elbe in Germany, but in Austria large quantities of Bohemian lignite are sent down the river to Dresden, Magdeburg and other river cities. Practically none of this coal reaches Berlin. On the middle section of the Elbe in the Province of Saxony and the Duchy of Anhalt, the shipments in 1909 were 1,969,016 tons, while the receipts were only 249,344 tons. Of the shipments, 1,558,863 tons were sent to Hamburg and 221,146 tons to Berlin and localities along the Mark waterways. The principal commodities sent to Hamburg were:

	Tons.
Phosphate	573,000
Dirt, sand, gravel, marl, etc	272,756
Refined sugar	258,595
Salt	86,464
Grain of various kinds	65,000

Of the receipts, 179,987 tons, or 80 per cent, consisted of Bohemian lignite from the Upper Elbe.

On the upper section of the Elbe, in the Kingdom of Saxony, in which is included the large city of Dresden, with a population in 1905 of 516,996, the shipments in 1909 were 464,906 tons, of which 296,957 tons went to Hamburg and only about 50,000 tons to Berlin and vicinity. These shipments were composed for the most part of high-grade products, such as glassware, crockery, paper, etc. The receipts in this traffic district amounted to 518,714 tons, of which 424,860 tons came from Hamburg and 376,700 tons from Austria. About one-third of the receipts from Hamburg consisted of grain of various kinds and grain products, the remainder being divided among a large number of miscellaneous articles, while Bohemian coal, amounting to 260,609 tons, was the principal commodity received from Austria. On the whole, the traffic is more varied and a relatively larger proportion of high-grade freight is carried on the Elbe than on any other European river.

The most important item of traffic on the Upper Oder is Silesian coal, which is brought to Kosel, Breslau, and other ports by rail and transshipped to river barges. A large part of this coal traffic is destined for Berlin and neighboring cities. In 1909 the total shipments in the traffic district which extends from Oppeln to Kosel, amounted to 1,311,553 tons, of which 1,159,238 tons were destined for the three traffic districts, including Berlin and cities along the Mark waterways. Practically the whole of this traffic, or 1,101,694 tons, consisted of Silesian coal. The shipments from the traffic district of Breslau on the Oder in 1909 amounted to 572,280 tons, of

which 125,137 tons passed through the connecting waterways to the Elbe and the port of Hamburg, and 407,150 tons to Berlin and communities along the Mark waterways. About 100,000 tons of the shipments to Hamburg consisted of raw sugar, and 266,990 tons of the shipments to Berlin consisted of coal.

The larger portion of the receipts at Berlin and suburbs comes from localities along the Mark waterways and is brought from a comparatively short distance. In 1909 this traffic amounted to 5,672,836 tons, of which 2,944,753 tons, or more than 50 per cent, was composed of bricks, tiles, and building stones, and 2,000,000 tons, or 38 per cent, of sand, gravel, marl, and commodities of a similar nature. An important reason for the growth of Berlin has been the ability to obtain cheap building materials.

There are two important reasons why the import traffic on the German rivers has increased more rapidly than the export traffic. The German seaports, as well as the Dutch and Belgian seaports at the mouth of the Rhine, are all located some distance inland from the coast, so that it is possible for river barges to run alongside the ocean-going vessels in the estuaries in perfect safety and receive their cargoes direct. The cost of transfer in this way is much cheaper than from steamship to freight car. For instance, Peters states that in 1903 the cost of transporting grain by water from Hamburg to Berlin, including transshipment charges, averaged from 2½ to 3½ marks, while the cost of transshipping grain from ocean vessels to freight cars alone averaged about 3 marks, or almost as much as the total cost by water.[1] Another reason is that it has been the policy of the Government to charge high rates on its railways for grain and other commodities imported in order to protect the home producer. The river rates are not subject to the same control, and are therefore much lower. For instance, in the case just mentioned, the rail rate was 13.8 marks, plus 3 marks for transfer, while the highest water rate was only 3½ marks. Since 1870 rail rates on imported cereals have increased, while the water rates have declined.

The cheap importation of grain by river in Germany is responsible for the hostility of agrarians to the improvement of waterways by the Government. Prof. Schumacher, the economist, points out that from 1896 to 1899 the railways handled only 3,000,000 out of 15,000,000 tons of import grain traffic.[2] In other words, the waterways handled 80 per cent of the business. In 1906 only 100,000 tons of cereal imported into the Rhine basin came by rail and 3,000,000 tons by water.

Belgium is one of the most thickly populated countries of Europe Its area is only 11,373 square miles, while its population in 1908 was 7,386,000. This gives a density of 649.43 persons per square mile. The following are the largest cities in Belgium and the population of each on January 1, 1908:[3]

Antwerp	594,523	Charleroi	414,679
Brussels	995,950	Mons	259,381
Ghent	405,976	Liege	529,239

[1] Max Peters, Schiffahrtsabgaben, in Schriften des Vereins für Socialpolitik, 115, pt. 3, p. 172.
[2] Cf. Louis Marlio, La Politique Allemand, p. 19.
[3] Annuaire Statistique de la Belgique, 1908, p. 43.

The dense population centered in the different cities gives rise to a large demand for those coarse freights and food products which are naturally transported by water. These must be imported from other countries. The main source of business for the inland waterways is the import traffic which arrives at Antwerp, where as already explained most of the principal rivers focus, and also that received from Holland and Germany on the north and France on the south, with whose waterways the Belgian system is connected. Rhine boats come into Belgium from Holland and ply through all parts of the system, and a ready exchange of traffic is also possible between the Belgian and the French waterway systems, owing to the numerous connections and also to the fact that the main lines in both countries are standardized to accommodate the same type of boat. This international traffic forms a very important part of the total business of the waterways. In 1905 the commerce with Holland and Germany was 9,000,000 tons and with France 3,000,000 tons.

Coal forms the principal item of traffic on the Belgian waterways, as shown by the following table:[1]

Classification of total traffic on the Belgian waterways for the years 1905 and 1908 in ton-miles and per cent.

Classification of goods.	1905		1908	
	Total ton-miles.	Per cent.	Total ton-miles.	Per cent.
1. Coals and coke	196,640,433	27.7	390,646,513	32.6
2. Building materials, stone, gravel, etc	127,892,374	18.0	228,130,330	19.1
3. Agricultural produce and foodstuffs	123,740,710	17.5	162,323,054	13.5
4. Metallurgic industry, metals, ores, pig iron, joists, rails, etc.	71,531,453	10.1	121,850,534	10.1
5. Pottery and glass industry	57,613,555	8.2	93,315,510	7.8
6. Industrial products	27,750,832	3.9	47,435,826	3.9
7. Wood (fire and constructional)	19,834,220	2.8	32,200,076	2.7
8. All others	83,357,621	11.8	124,101,779	10.3
Total	708,361,198	100.0	1,200,003,622	100.0

The import coal traffic on the Belgian waterways is much larger and is increasing more rapidly than the shipments of domestic coal used within the country The export coal traffic is also larger than the amount of domestic coal transported by water, as the following table for 1906 indicates:

	Tons.
Imported	2,178,932
Exported	1,596,000
Domestic	750,000
Total	4,524,932

The reason for the predominance of imported coal in that the domestic coal is hauled for such short distances that there is no economy in water transportation. Of the 11,483,705 tons of coal hauled on the State railways in 1906, 8,122,390 tons, or 74 per cent, were hauled a distance of not more than 37½ miles.[2]

[1] Lindley, page 175, and Annuaire Statistique de la Belgique, Brussels, 1910, p. 415.
[2] Vide, p. 545, infra.

The following table shows the total importations of coal from different countries by sea, by rail, and also by inland waterways:[1]

From—	By sea.	By rail.	By inland waterways.
	Tons.	*Tons.*	*Tons.*
Germany		1,797,186	1,782,586
England	1,460,191	74,287	18,392
France		496,573	370,049
Holland		54,707	7,905
Total			2,178,932

The growth of the import coal traffic for the period 1897–1906 and the different waterways on which it is carried, is shown by the following table:

Principal waterways.	1897	1906	Increase.
	Tons.	*Tons.*	*Tons.*
Sambre, canalized	907	7,185	6,278
Canal de Mons à Condé	4,138	6,518	2,380
Haut-Escaut	141,037	162,425	21,388
Lys	259,281	261,397	2,116
Escaut maritime	266,645	844,462	577,817
Canal de Gand à Terneuzen	223,423	298,008	74,585
Canal de Bois-le-Duc	34,517	299,439	264,922
Total	929,948	1,879,434	949,486

The coal from England arrives at Antwerp in ocean-going vessels and is transshipped to barges to be taken inland. The coal arriving by rail from foreign countries is never transshipped to waterways, but is carried directly to the point of consumption. Much of the coal arriving from Duisburg-Ruhrort in Rhine boats passes through Antwerp without breaking bulk and circulates through the Belgian system to the various industrial centers.

The coal imported from France comes by the rivers and canals connecting with the French waterway system, especially through the canalized Sambre, Escaut, and Lys, and the Canal de Mons à Condé, and the Canal Nieuwport à Dunkerquée.

The total exports of coal from Belgium by sea, by rail, and by inland waterways is shown by the following table. As will be seen, the largest exports of coal by inland waterways as well as by rail are to France.[2]

To—	By sea.	By rail.	By inland waterways.
	Tons.	*Tons.*	*Tons.*
France	7,920	2,952,686	1,357,905
Germany	6,035	234,727	102,322
Holland	205	237,437	113,276
Switzerland		68,834	
Italy	11,545		

[1] Annals des Travaux Publics de Belgique, 1908, p. 938.
[2] Ibid, p. 945.

The exports of coal to France, Holland and Germany by inland waterways go by four routes only. On the Sambre this export coal traffic has decreased slightly during the last nine years, while on the other three routes, as shown by the following table, this traffic has increased considerably: [1]

Waterway.	1897	1906	Differences.
	Tons.	*Tons.*	*Tons.*
Sambre	584,841	542,213	42,628
Meuse	567,840	791,571	223,731
Canal de Mons à Condé	171,844	180,468	9,434
Canal de Bois-le-Duc	38,694	81,748	43,054
Total	1,363,219	1,596,000	232,681

Building materials, stone, gravel, etc., constitute a class of traffic which in Belgium is transported almost entirely by water. In 1908 it amounted to 228,000,000 ton-miles, or 19 per cent of the total ton-mileage on the Belgian waterways. This is the principal item of domestic traffic, and is carried for comparatively short distances. Agricultural produce and foodstuffs in 1908 amounted to 162,000,000 ton-miles, or 13½ per cent of the total ton-mileage on the Belgian waterways. A considerable proportion of this traffic is grain imported at Antwerp and transshipped from ocean-going steamers into river barges for distribution to interior points. Some of it is imported from Holland and France by the inland waterways.

The main sources of traffic in France, as in Germany and Belgium, are, first, the import and export traffic; and, secondly, the transportation of raw products from mines, quarries, or farms adjacent to the waterways to the large cities. The different classes of commodities transported on the inland waterways of France for the year 1907 are shown by the table which follows. It will be seen that the first three classes alone comprise more than 78 per cent of the total traffic.[2]

Classes of merchandise.	Number of tons transported.			Percentage of each group.[3]
	Rivers.	Canals.	Total.	
1. Coal, coke, etc	3,461,158	7,503,644	10,964,802	31.6
2. Building materials, stone, gravel	7,583,659	4,489,422	12,073,081	34.8
3. Agricultural and food products	1,799,809	2,468,051	4,267,860	12.3
4. Wood and lumber of all kinds	784,542	945,639	1,730,181	5.0
5. Raw materials for metallurgy	417,807	1,298,855	1,716,662	4.9
6. Fertilizers and manures	867,756	701,953	1,569,709	4.5
7. Manufactured products	532,321	623,961	1,156,282	3.3
8. Metals and machinery	307,535	451,300	758,835	2.2
9. Miscellaneous	196,474	133,002	329,476	1.0
10. Rafted timber of all kinds	111,883	22,844	134,727	.4
Total	16,062,944	18,638,671	34,701,615	100

[1] Annals des Travaux Publics de Belgique, 1908, p. 957.
[2] Statistique de la Navigation Interieure, 1907, p. 45.
[3] The variations from these figures in 1910 was less than 1 %.

The waterways having the largest traffic all center in the city of Paris, whose population in 1906 was 2,763,393. While the density of population for the whole of France is 190 persons per square mile, that of the Department of the Seine is several thousand. Thus this densely populated district furnishes the main center of demand for food supplies and raw products of all kinds.

The vast importance of water-borne traffic for the city of Paris will be shown by the following condensed exhibit of the commerce of this port during the 13 years from 1898 to 1910, inclusive:[1]

Year.	Number loaded vessels.	Total weight cargoes.	Shipments.	Arrivals.	Transit.	Local traffic.
		Metric tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1898	46,457	9,164,825	1,814,196	5,280,788	1,418,806	651,035
1899	52,048	10,481,483	2,662,221	5,848,370	1,321.855	649.037
1900	46,174	9,301,491	1,484,152	5,699,861	1,437,324	680,154
1901	44,721	8,900,684	1,704,510	5,197,808	1,432,410	565,956
1902	45,653	9,238,056	1,960,894	5,354,405	1,370,850	551,907
1903	48,111	9,857,146	2,329,999	5,694,952	1,345,968	486,227
1904	49,235	10,130,830	2,421,110	5,689,027	1,465,743	454,950
1905	50,192	10,202,828	2,507,747	5,763,864	1,504,506	426,711
1906	50,904	10,525,136	2,490,238	6,273,610	1,390,280	371,008
1907	50,109	10.845,558	2,342,359	6,310.861	1,793,809	398,529
1908	47,519	10,529,267	2,264,934	6,297,736	1,602,797	345,800
1909	48,741	10,940,525	2,566,090	6,197,414	1,809,801	367,220
1910	51,316	10,330,758	2,357,712	6,563,749	1,059,451	349,846

If this record is extended backward so as to include the year 1884, it will be found that during the period of 27 years ending with 1910 the total weight of cargoes has increased 93.56 per cent; the shipments, 314.89 per cent; the freight arriving, 69.41 per cent; freight in transit, 188.11 per cent; while local traffic has decreased 33.56 per cent per annum.

The commerce on the River Seine consists largely of import and export traffic between Paris and the seaports of Havre and Rouen. The upstream traffic greatly exceeds the shipments downstream, and coal forms the principal commodity in the former class. About 60 per cent of all the traffic which passes through the maritime section of the Seine between Havre and Rouen consists of cargoes of coal.

At the latter port the coal is transshipped from the ocean-going vessels to barges and towed up the river to Paris. In 1906 1,836,097 tons of coal were imported at Rouen and 1,156,411 tons were sent up the river.[2] In 1907 1,287,883 tons of coal were transported upstream from Rouen. Most of this coal comes from England and Wales. The round trip from Rouen to Wales, including the time consumed in loading and unloading, can be made in eight days. Agricultural and food supplies form the next largest item imported. Most of this traffic is also transshipped to river barges at Rouen from ocean-going vessels.

[1] Statistique de la Navigation Interieure, 1910, p. 120.
[2] Notice sur le Port de Rouen, 1908, p. 7.

The following table shows the predominance of upstream traffic on the Seine from Havre and Rouen to Paris, and also the predominance of coal and food supplies in this upstream traffic. A much larger share of this traffic is transshipped at Rouen than at Havre.[1]

Sections of river.	Total traffic.	Traffic upstream.	Coal upstream.	Grain and food supplies upstream.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Seine from Havre to Rouen	394,892	287,962	24,827	139,163
Seine from Rouen to mouth of the River Oise	3,014,500	2,539,809	1,287,883	504,829
Seine from the Oise to La Briche[1]	6,457,632	5,471,217	3,911,874	530,431
Seine from La Briche to Paris	5,281,478	3,751,770	2,777,566	350,626

[1] The River Oise is a part of the northeastern route on which, as shown below, there is also a heavy coal traffic in the direction of Paris.

The major part of traffic on the Seine above Paris is downstream to the city and consists mostly of building materials, wood, and grain. Likewise on the Marne, which joins the Seine near the city limits, the bulk of the downstream traffic consists of building materials. They contributed in 1907, 459,206 tons out of a total downstream traffic of 625,462 tons.

Next to the import traffic on the River Seine, the most important source of business for the waterways leading to Paris is domestic coal from the fields of northeastern France and coal imported from Belgium. This is brought to Paris by the northeastern waterways. On this route the downstream traffic is three or four times as great as the upstream traffic, and consists largely of coal. The accompanying tables for the main line and its two branches show the percentage of coal transported in the direction of Paris.[1]

Main line.

Sections.	Total traffic.	Traffic toward Paris.	Coal, coke, etc., toward Paris.	Percentage of coal, coke, etc., in traffic toward Paris.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1. River Oise, from Janville to the Seine	4,370,239	3,397,409	2,970,747	87.5
2. Canal, lateral to the Oise	5,966,179	4,359,554	3,931,720	90.2
3. Canal, St. Quentin	6,795,174	4,892,127	4,323,197	88.4
4. River Escaut, from Cambrai to Étrun	5,567,147	4,206,735	3,831,327	91.1

The main line just described divides at Étrun into two branches, one proceeding in a northwesterly direction toward the seacoast near Calais, and the other following the river Escaut to the Belgian frontier, where it connects with the Belgian waterway system. The predominance of coal traffic on these branches is also marked.

[1] Statistique de la Navigation Interieure, 1907. Later statistics show an even greater predominance of coal.

1.—*Northwestern branch.*

Sections.	Total traffic.	Traffic toward Paris.	Coal traffic toward Paris.	Percentage of coal traffic.
	Tons.	*Tons.*	*Tons.*	
Canal de la Sensée	4,300,133	3,428,302	3,210,032	93.6
River Scarpe around Douai	4,003,545	3,219,436	2,982,723	92.6
Canal de la Deûle (Haute)	5,685,686	3,802,407	3,395,827	89.3
Canal d'Aire and branch	4,109,648	2,761,581	2,130,469	77.1
Canal de Neuffossé	1,952,739	1,024,033	658,557	64.3
River Aa	2,088,285	1,097,192	608,778	55.5

2.—*Northern Branch.*

Sections.	Total traffic.	Traffic toward Paris.	Coal traffic toward Paris.	Percentage of coal traffic.
	Tons.	*Tons.*	*Tons.*	
River Escaut from Étrun to Condé	2,087,463	1,204,195	876,776	72.8
River Escaut from Condé to Belgian frontier [1]	647,523	207,839	126,050	60.6

[1] From Condé the predominance of traffic is downstream toward Antwerp. Of the 439,684 tons shipped in this direction, 154,388 tons were coal and 157,365 tons building materials.

Building materials, stone, gravel, etc., constitute the largest class of upstream traffic on this northeastern route. A considerable amount of agricultural products and foodstuffs are also transported upstream.

Some of the waterways in the eastern part of France show a large traffic independent of that to and from Paris. The bulk of this traffic also consists of coal from the mines of the northeast, intended for distribution to the interior industrial centers of France. The main line of this traffic is shown by the following table:

Sections.	Total traffic.	South-bound.	Coal south-bound.	Percentage of coal south-bound.
	Tons.	*Tons.*	*Tons.*	
Canal from the Oise to the Aisne	2,008,062	1,181,123	974,032	82.5
Canal, lateral to the Aisne	2,543,322	1,429,402	939,312	65.7
Canal, from the Aisne to the Marne	2,003,484	1,255,853	915,900	73.0
Canal, lateral to the Marne	2,036,648	1,082,030	677,994	62.7

On this route it is seen that the traffic is more evenly distributed between the two directions than is the case around Paris. While coal predominates in the southbound traffic, the northbound is divided among wood, grain, and heavy manufactured steel and iron products.

Belgian coal also contributes largely to the southbound traffic of both the eastern and northeastern waterways. It is brought to the frontier either by the canalized Sambre, which is connected by canal with the River Oise, or by the canalized Meuse, which joins the northern branch of the Canal de l'Est at the boundary. The predominance

of Belgian coal in the southbound traffic of these two routes is shown by the following table:

Sections.	Total traffic.	South-bound traffic.	Coal south-bound.	Percentage of coal south-bound.
	Tons.	*Tons.*	*Tons.*	
Canalized Sambre from frontier to Landrecies	825,287	629,360	579,056	92.0
Canal from the Sambre to the Oise	874,544	648,647	557,644	86.0
Canal de l'Est, northern branch	1,849,064	1,129,515	806,578	71.4

The five tables given above include practically all of the important waterways of France. In the central part of the country and in the basin of the Rhone the water-borne commerce is much smaller. The traffic of the Rhone is largest on the section between Lyon and Arles. In 1907 it amounted to 670,292, of which 354,093 tons, or more than half, consisted of building materials, and 122,136 tons, or one-third, of grain and agricultural products. There is very little coal transported on the Rhone. A small amount is imported from the Mediterranean. The Saône from Lyon, where it joins the Rhone to Carre, where it connects with the southern branch of the Canal de l'Est, has a commerce averaging about 600,000 tons. The southbound traffic is about double the northbound, and nearly 40 per cent of the former consists of Belgian and domestic coal received from its connection with the northern waterways.

Most of the traffic on the waterways of England consists of coal, iron ore, and pig iron; also building materials, sand, gravel, clay, and some grain. On a number of the waterways coal forms the bulk of traffic, as shown by the following table: [1]

Waterway.	Total tonnage, 1905.	Coal tonnage.	Percentage of coal to total tonnage.
Manchester, Bolton, and Bury	654,149	567,345	87
Aire and Calder	2,810,988	1,911,470	68
Sheffield and South Yorkshire	835,982	487,757	58
Leeds and Liverpool	2,467,827	1,277,779	51
Birmingham Canal	7,546,453	3,785,655	50

As already stated, most of this traffic is carried from mines adjacent to the canal to manufacturing concerns located upon its banks. Except for the Aire and Calder there is practically no import or export traffic carried on the waterways of England, although this forms the main source of business for the railways. England has densely populated cities and extensive manufacturing industries which require the cheap importation of raw products. She also has an abundance of coal and building materials such as furnish the traffic for the waterways of other European countries. If the other factors were as favorable as the economic conditions, inland water transportation should flourish.

[1] Report of Royal Commission, Vol. VII, p. 61.

The necessity of having large supplies of coarse, raw materials, if water transportation is to assume large proportions, is nowhere better illustrated than on the Great Lakes. In 1910, as the table below indicates, the total receipts and shipments at all the lake ports in the United States amounted to 171,146,952 short tons, 54 per cent of which consisted of iron ore and 21.5 per cent of soft coal.[1]

Total receipts and shipments, by commodities, for 1910.

[Total receipts, 84,414,636 short tons; total shipments, 86,732,316 short tons.]

	Receipts.		Shipments.	
	Tons.	Percentage of total.	Tons.	Percentage of total.
Iron ore	46,376,411	54.9	46,499,758	53.6
Soft coal	18,401,700	21.8	18,406,469	21.2
Flour	1,169,911	1.4	1,171,327	1.4
Wheat	1,101,219	1.3	1,115,381	1.3
Corn	769,848	.9	948,526	1.1
Oats, barley, rye, flaxseed	926,045	1.1	973,776	1.1
Unclassed	15,669,502	18.6	17,617,079	20.3

The principal iron ore beds are located near Duluth and other Lake Superior ports. The great bulk of the iron ore traffic is carried to the Lake Erie ports and there transshipped to rail for distribution to the iron and steel centers of Pittsburgh and the Mahoning Valley. The soft coal from the mines in Pennsylvania and West Virginia forms the bulk of the return traffic over this route. Thus the great artery of commerce on the Great Lakes passes through the Sault Ste. Marie Canals. In this traffic, as shown by the table below, iron ore and coal form an even larger percentage than they do of the total receipts and shipments at the Great Lake ports.

Percentages of principal commodities passing through the Sault Ste. Marie canals during the last decade.[1]

Commodity.	1900	1905	1907	1909	1911	General direction.
Iron ore	64.1	70.8	68.0	70.0	57.4	Eastbound.
Coal	17.5	14.7	19.6	17.3	28.7	Westbound.
Wheat	4.8	4.6	5.1	5.9	5.5	Eastbound.
Other grains	1.5	2.1	1.8	1.1	1.8	Do.
Flour	2.6	1.3	1.1	1.2	1.4	Do.
Lumber	6.0	3.7	1.9	1.3	2.2	Do.
General merchandise	2.1	1.9	1.8	2.0	2.6	90 per cent westbound.

[1] Compiled from the Monthly Summary of Commerce and Finance and from the report of the Engineer in charge, for 1911.

The following six tables, compiled from the monthly summary of commerce and finance for December, 1910, shows, in parallel columns, the ports from which the main articles of traffic on the Great Lakes are shipped, and the ports at which they are received.

[1] Compiled from the Monthly Summary of Commerce and Finance, December, 1911.

The principal commodities carried over the main course of the Great Lakes during the year 1910.

I.—IRON ORE.

[Total shipments, 41,517,641 long tons; total receipts, 41,507,626 long tons.]

Ports of origin.	Shipments.	Ports of destination.	Receipts.
Ashland	3,867,011	Ashtabula	9,626,897
Duluth	13,548,569	Buffalo	4,066,158
Escanaba	4,799,558	Cleveland	6,356,762
Marquette	1,621,782	Conneaut	6,318,135
Superior-West Superior	8,245,225	Fairport	1,516,471
Two Harbors	7,958,060	Lorain	2,830,481
		Toledo	1,166,198
		Chicago-South Chicago	5,120,165
		Gary	1,775,407

II.—SOFT COAL.

[Total shipments, 18,406,469 short tons; total receipts, 18,401,700 short tons.]

Ports of origin.	Shipments.	Ports of destination.	Receipts.
Ashtabula	4,539,147	Ashland	642,938
Cleveland	2,952,855	Duluth	2,099,381
Lorain	2,300,644	Green Bay	684,919
Sandusky	1,255,607	Manitowoc	868,783
Toledo	4,112,262	Superior-West Superior	5,020,165
Huron	760,187	Chicago-South Chicago	605,456
Conneaut	534,709	Milwaukee	3,987,358

III.—WHEAT.

[Total shipments, 37,179,364 bushels; total receipts, 36,707,315 bushels.]

Ports of origin.	Shipments.	Ports of destination.	Receipts.
Chicago-South Chicago	8,536,882	Buffalo	32,007,382
Milwaukee	3,742,556	Clevaland	1,014,800
Duluth	13,049,317	Detroit	728,998
Superior-West Superior	11,747,159	Toledo	665,839
		Chicago-South Chicago	1,473,000

IV.—CORN.

[Total shipments, 39,521,929 bushels; total receipts, 32,284,915 bushels.]

Ports of origin.	Shipments.	Ports of destination.	Receipts.
Chicago-South Chicago	35,841,997	Buffalo	22,981,573
Milwaukee	2,506,963	Detroit	630,000
Superior-West Superior	546,519	Cleveland	748,543
Manitowoc	493,414	Ludington	1,264,129
		Ogdensburg	4,302,732
		Port Huron	1,798,590

V.—OATS.

[Total shipments, 22,659,792 bushels; total receipts, 20,669,747 bushels.]

Ports of origin.	Shipments.	Ports of destination.	Receipts.
Chicago-South Chicago	6,954,423	Buffalo	11,232,164
Gladstone	1,309,149	Cleveland	1,185,846
Kewaunee	972,397	Frankfort	1,038,970
Manitowoc	4,306,139	Grand Haven	549,492
Milwaukee	4,674,845	Ludington	5,912,574
Duluth	1,239,655	Port Huron	460,500
Superior-West Superior	3,017,673		

VI.—FLOUR.

[Total shipments, 1,171,327 short tons; total receipts, 1,169,911 short tons.]

Ports of origin.	Shipments.	Ports of destination.	Receipts.
Chicago-South Chicago	283,872	Buffalo	749,137
Gladstone	52,720	Erie	140,467
Milwaukee	310,368	Fairport	54,816
Duluth	166,375	Grand Haven	73,304
Superior-West Superior	289,514	Ludington	103,270
Manitowoc	60,500	Ogdensburg	18,642
		Port Huron	14,940

The lack of an abundant supply of coarse, bulky freights, coupled with the lack of large population or industries near the rivers to demand such commodities, has been a very important factor in the decline of river traffic in the United States. In the first place, the population, especially in the interior, is very sparse in comparison with that of European countries. Except for the Lake ports there are comparatively few large cities located on the inland waterways. On the average, there are only 31 inhabitants per square mile in the United States, while along many of our rivers the density of population is much less. Railway competition has been more severe than in Europe, with the result that the business of the waterways has been confined to a very few commodities. Not only the miscellaneous freight has deserted the waterways, but also most of the coarser freights. On some rivers lumber has furnished the principal source of traffic for a time, but it is of a temporary character, owing to the depletion of the forests. Grain and cotton, which once were carried in large quantities on the Mississippi, are now carried almost entirely by rail.[1] The only rivers that have maintained a large commerce in competition with the railways are those which possess exceptional advantages for the transportation of coal. The Monongahela is the most important river in this class. Coal can be loaded directly from the mines into river barges and floated downstream to the mills and factories, where it is consumed. The Kanawha possesses similar advantages, but its market is not so convenient.

The first table below shows the traffic on the Monongahela for the last six years, by commodities. Most of this coal is consumed in the Pittsburgh district. Some of it is transported down the Ohio River for consumption at the different river ports, and a small percentage of it is sent each year as far as New Orleans. The second table shows the amount of traffic by commodities passing through Dam No. 1 in the Ohio River below Pittsburgh.

Traffic through locks on Monongahela River from 1906 to 1911, inclusive.

	1906	1907	1908	1909	1910	1911
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Coal	9,729,861	10,822,169	8,191,910	9,746,326	9,472,835	9,207,232
Iron and steel	58,297	69,859	96,450	144,335	146,580	184,568
Sand and gravel	1,688,413	1,763,630	1,268,362	1,533,187	1,217,239	1,278,295
Timber and lumber	38,363	26,775	11,366	18,509	28,153	20,046
Miscellaneous	23,294	46,171	39,000	43,921	62,623	56,900
Total	11,538,228	12,728,604	9,607,088	11,486,278	10,927,430	10,747,041

Traffic through Lock and Dam No. 1, Ohio River, from 1906 to 1911, inclusive.

	1906	1907	1908	1909	1910	1911
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Coal	2,883,965	3,206,727	1,745,159	2,466,710	1,774,760	2,816,975
Iron and steel	88,180	33,955	38,022	55,167	45,663	59,025
Sand and gravel	24,415	682,730	1,224,082	1,220,340	1,166,065	1,134,540
Timber and lumber	12,130	21,621	9,953	22,486	25,127	20,194
Miscellaneous	82,507	76,773	43,619	56,944	128,918	74,915
Total	3,091,197	4,021,806	3,060,835	3,821,647	3,140,533	4,106,64

[1] The economic reasons for the decline of traffic on the Mississippi are well set forth in Dixon's Traffi History of the Mississippi River, National Waterways Commission Doc., No. 11; also in the report by a special Board of Engineers on Survey of Mississippi River, Appendix 20 (H. Doc. No. 50, 61st Cong., 1st sess.).

On the Mississippi River from St. Louis to Memphis, coal and coke from the Ohio form about 50 per cent of the total receipts and shipments and is the principal item of through traffic in the lower two sections of the river, inasmuch as stone, gravel, and sand and also lumber and logs are transported for much shorter distances.

Receipts and shipments for 1910.[1]

Sections.	Total tonnage.	Coal and coke.	Stone, gravel, and sand.	Lumber and logs.	Grain and and its products.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
St. Louis to Cairo	289,759	113,673	45,314	50,341	16,981
Cairo to Memphis	1,039,195	508,696	21,481	408,542	15,669
Memphis to Vicksburg	980,386	392,561	186,516	147,328	20,295
Vicksburg to New Orleans	1,530,230	364,559	657,655	86,441	28,470

[1] Compiled from the report of the Secretary of the Mississippi River Commission.

It is an interesting fact also that on those rivers along the Atlantic coast which are deep enough to accommodate coastwise vessels and at most of the harbors coal is one of the principal articles of commerce notwithstanding railroad competition, while at points which the railways do not reach miscellaneous freight of all kinds is brought by boats. On the Merrimac, for instance, 99 per cent of the traffic is coal brought in ocean barges; on the Connecticut below Hartford coal contributes 410,148 tons of a total of 636,874 tons. On the St. Croix River in Maine the total traffic in 1910 amounted to 161,416 tons, of which 75,000 tons was coal and 75,420 tons lumber. Likewise on the Penobscot in Maine 244,666 tons of coal and 228,497 tons of lumber and cooperage comprised the principal items of traffic out of a total tonnage of 566,434.

The foregoing analysis of the traffic carried on the principal waterways of Europe and the United States reveals the fact that a few bulky commodities form the great share of the tonnage. Among these coal is the most conspicuous. In many cases it furnishes more than 50 per cent of the total traffic, and sometimes as high as 90 or 95 per cent. The cases are rare on the principal waterways where coal is not the largest single item carried. On the Mark waterways it is surpassed by brick and tiles carried to Berlin, and on the Great Lakes it is surpassed by the iron-ore traffic. In a few other cases it is surpassed by sand, gravel, and building stone. But in general it might almost be said that no waterway will have a large traffic unless it is so situated as to afford a route for the cheap transportation of coal. To cause the movement by water of this commodity and others of like kind the sources of supply must be accessible to a waterway or close enough to be made accessible by a short rail haul. In this respect sand, gravel, etc., have the greatest advantage, for they are generally obtained directly from the bed or banks of a river. In Europe the imports also supply much of the traffic carried by the principal rivers. There must also be large centers of population or large factories to use these commodities in full boat loads in order that the greater economy of water transportation may be realized. Water transportation is never successful in supplying the needs of a small scattering population which consumes raw products in small units unless it is the only means of

transportation available. In this event its traffic is not confined to the lower grades of freight.

With these facts in mind, the fundamental reason for the small traffic carried on many of the rivers of the United States is not difficult to understand. There are only a few cases where the economic conditions are so favorable for the growth of inland water transportation as in Europe. The rivers serving Pittsburgh are the best examples, especially the Monongahela. The coal mines adjacent to the river furnish the traffic and the numerous steel and iron industries along the river front in the Pittsburgh district furnish the principal consumers. Large quantities of sand and gravel are also taken from the Allegheny, Monongahela, and Ohio and transported to Pittsburgh for building purposes.

V.

The Relations Between Railways and Waterways.

An essential factor for the success of water transportation is the existence of amicable relations between the railways and waterways. A country may possess fine rivers, well improved, and may also have a large population and an abundance of coarse, bulky commodities requiring transportation, but if the railways are allowed a free hand, they will divert most of this traffic from the waterways, even though the latter may afford cheaper transportation. In competing with waterways the railways have a distinct advantage. Only a small portion of their traffic is suited for water transportation. As a rule, little competition is possible on their passenger, express, and high-grade freight business. On the other hand, pactically all the traffic of a waterway may be subject to rail competition. Furthermore, the railroad competes with the water route only at comparatively few points, when the whole system is taken into consideration, while the water route is usually in competition with the railway at almost all points. Under such conditions the railroad can recoup itself for losses incurred by rate cutting on a few commodities and at a few points from the profits it makes on all the traffic not affected by water competition, while the water carrier, financially much weaker and having few, if any, way stations where it enjoys a monopoly of the business, has little opportunity to recoup itself anywhere. Thus the two never compete on equal terms and the relative cost of transportation, which should be the deciding factor, ordinarily makes little difference in the outcome of the contest. In the long run if the railway forces the competition the water carrier is almost certain to succumb. Only on large bodies of water has it any chance at all.

A railway may also greatly limit the business of a waterway by preventing the exchange of traffic between the two. This can be accomplished by charging high local rates to and from transshipment points and by refusing to make prorating arrangements with water carriers and to establish suitable connections with their terminals. In this way the inconvenience and cost of transferring freight is greatly increased. This method of competition becomes most prominent when the railway system is fairly complete and the different roads are working in harmony. As long as a waterway acts as a feeder for a railway cooperation for the exchange of traffic will be manifest.

It may prove cheaper for a railway to control water carriers than to compete against them, especially when the natural advantages of the former are great. Thus it was the policy of railroads at one time to purchase outright or secure a controlling interest in competing canal companies. The common method in the United States now is for the railways to own or control boat lines. Where they also own the terminal facilities at a port it is a very easy matter to prevent serious competition from independents. The view was once held that the waterways were free highways on which competition would always exist, but what has transpired in the United States during the last decade indicates that even water transportation may be monopolized or so effectively controlled that it is hazardous for independent boat lines to enter the field.

The experience of all countries has been that as long as the railways were not subject to strict control, they have succeeded in crushing out or controlling water competition. The regulation of railway activities for the protection of water carriers has, accordingly, been found necessary in all countries before the normal development of water transportation could take place.

THE CONTROL OF RAILWAYS AND WATERWAYS.

The protection of water transportation in European countries has been accomplished in several different ways. Where the State owns both the railways and waterways, as in Germany and Belgium, the problem is much simplified. Both means of transportation are then, as a rule, under the supervision of one department of the Government and are administered in the interest of the public. In such countries it is unusual for a government-owned railroad to cut rates in direct competition with a government-owned water route. Protection of this kind is most complete in Germany and Belgium, but it also exists in Russia, as well as in Austria-Hungary. In the latter countries the Government is extending its control over the railways either by ownership or by the lease and operation of private companies, so that in recent years severe competition against the waterways has been much less marked. In Holland there has been little opportunity for competition between railways and waterways. There are only two important railway systems in the country. One of these is owned by the State but is leased and operated by a private company, under strict control. The other is owned and operated by a private company. In both cases the rates are fixed by the minister of waterstaat, and they can not be changed except with the consent of the Government.

In France five of the seven railway systems are still owned and operated by private companies. This has made the problem of protecting waterways against railway competition more difficult than in Belgium or Germany. No special legislation for this purpose has been enacted, but the strict control exercised over railway rates has been successfully used to prevent direct competition against the waterways. Before a railroad company can raise or lower its rates, the proposed modification must be passed upon by the consultative committee and confirmed by the minister of public works who usually follows its recommendation. Where water competition exists, the committee as a matter of principle usually requires a 20

per cent differential in favor of the waterways and includes in its consideration any excessory charges with which water traffic may be burdened.[1] In particular cases the protection allowed a waterway may be much greater than 20 per cent and in other cases considerably less. A good instance of the former occurred in the case of the Western Railway in 1905 when it was still operated by a private company. The railroad company proposed a reduction of the rate on cement and this proposal was rejected by the committee, although allowing the competing waterway a margin of 33 per cent. Occasionally it happens that a water rate is higher than the competing rail rate. For instance the rate on coal transported by the St. Quentin Canal sometimes rises above the rail rate during periods of heavy traffic. This is due to the fact that at such times there is more traffic than the railways and the waterways combined can accommodate, and while the rail rate is fixed, the water rate is not, and rises in response to the increased demand for shipping facilities.

Another deterrent to the cutting of railway rates to eliminate water competition in France is the fact that a railway is usually required, when reducing its rate at a particular point, to grant similar reductions all along its lines in order to prevent local discrimination. Furthermore when a railway has obtained permission to put in force a lower rate, it can not raise it again without first obtaining the sanction of the consultative committee and the minister of public works. Under such circumstances the railways are very cautious about proposing reductions in competition with the water routes and the waterways have thus been assured of adequate protection from rate cutting. The efforts of the Government to compel railways to establish physical connection with the waterways have not been so successful.[2]

In England the Government owns neither the railways nor the waterways, and for this reason the problem of protecting water transportation has been especially difficult. Previous to 1845 the maximum tolls, rates and charges of canal companies had been fixed by law usually at a uniform rate per ton or per mile. The rapid absorption of canal companies by the railways which took place from 1840 to 1845, together with the marked decline of traffic on almost all the canals due to railway competition, led to numerous parliamentary inquiries and acts for the preservation of water transportation. Parliament little understood the problem, and at first proceeded on the theory that if the canals were granted the same privileges which the railways enjoyed, they would be able to compete successfully. Accordingly in the beginning the same regulations were imposed upon canal companies as upon the railways, and that policy has been followed in all subsequent legislation. In 1845 canal companies were given the power to vary their tolls according to the circumstances of the traffic, just as the railroads were allowed to do. They could charge less on one section of the canal than on another, or less for larger than for smaller quantities, providing they did not discriminate between shippers.[3] During the same year another act was passed which enabled canal companies to become carriers of goods on their own canals and to make working arrangements with other canal companies for the through passage of boats. The right

[1] cf. Lindley, Appendix III, p. 117.   [2] Vide, p. 552 infra.   [3] 8 and 9 Vict., c. 28.

was also granted to canal companies to lease others if they so desired.[1] It was hoped by this means to bring about the amalgamation of the disconnected and disunited canal companies so that they could more effectively compete against the railways, which were rapidly amalgamating into systems. These laws, however, accomplished little. The canal companies did not amalgamate; only a few became carriers, and the rapid decline of water transportation continued.

The railway and canal traffic act of 1854 also followed the policy of subjecting the canal companies to the same regulations imposed upon the railways. They were required to afford all reasonable facilities for receiving, delivering, or forwarding freight on through routes, and undue discrimination or favoritism was prohibited.[2] This act, however, contained no provision for the protection of water transportation against the competition of railways.

Beginning in the seventies, the Government sought to prevent the railways from securing further control over the canal companies. After an extensive investigation of this subject in 1872, the railway and canal traffic act of 1873 was passed.[3]

The canal companies and the railways were placed under the jurisdiction of the railway commission which the act created, and both were required to keep posted for public inspection all schedules of rates and charges. Section 16 of the act prohibited the making of any agreement which gave a railroad company control over the traffic or the rates or tolls charged on any part of a canal without the consent of the commission, and stated that the commission should withhold its sanction from any agreement which in its opinion was prejudicial to the interests of the public. This is the first provision in English law intended specifically to prevent the further elimination of water competition.

Section 17 of this act provided that every railway company owning or having the management of a canal or part of a canal should at all times keep and maintain such canal and all appurtenances in thorough repair and good working condition so that there should be no unnecessary hindrance or interruption or delay to persons desiring to use it. The purpose of this section was to prevent the railways from allowing the canals which they had acquired to deteriorate and become useless for navigation, as they had in some cases been guilty of doing.

The most important act regulating canal companies and also the relations between canals and railways was the railway and canal traffic act of 1888.[4] Part 3 of this act applies exclusively to canals. Section 36 states that all the provisions of part 2 of the act relating to railway companies, so far as applicable, should apply also to every canal company and to every railway and canal company. The principal requirement of part 2 was that the railways should file with the board of trade classifications and schedules of maximum charges. In accordance with section 36 such schedules were also drafted for 149 canal companies and confirmed by Parliament during the years 1893–94.

Section 38 provides that where it is proved to the satisfaction of the railway commissioners that the tolls, rates or charges on a canal are such as are calculated to divert the traffic from the canal to a

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[1] 8 and 9 Vict., c. 42.
[2] 17 and 18, Vict., c. 31, s. 2.
[3] 36 and 37 Vict., c. 48.
[4] 51 and 52 Vict., c. 25.

railway, they may, upon application, make an order requiring these tolls or rates to be reduced so that they shall be reasonable, as compared with the rates and charges for the conveyance of merchandise on the railway. If the order of the commissioners to alter and adjust these charges is not carried out, they may make such alterations and adjustments as they shall think just and reasonable, and these shall be binding upon the company or persons owning or controlling the canal. If this provision were strictly enforced, it would prevent railway companies owning competing canals from charging such high rates on them as to divert traffic to the railways. Apparently it has had little salutary effect; for instances were found by the royal commission on canals and inland waterways where the charges on the railway-owned section of a canal were four times as high as those upon the other sections.

Section 39 of part 3 empowers the board of trade to require from canal companies from time to time statements showing the capacity of their waterways for traffic and the capital, revenue, expenditure, and profits of the operating companies. The board of trade has only called for such returns twice since the passage of this act, once in 1898 and again in 1908. Hence the aim of this provision to obtain more intimate knowledge as to the exact condition of the canal companies has not been realized.

Section 42 is intended to prevent railway companies from acquiring control of the canal companies. It provides that no railway company or officer of a railway company shall, without express statutory authority, authorize or permit the use of the company's funds for the purpose of acquiring any canal interest. In the event of violation of this provision, the canal interest purchased is forfeited to the Crown, and the officials responsible for such purchase are liable for the payment of the amount spent for this purpose.

Section 43 permits canal companies to enter into contracts for the through passage of boats and traffic, and permits lower tolls, rates, and charges for through traffic than those fixed by law for each canal. Section 44 permits canal companies to establish a canal clearing system for the division of through rates. The aim of these two provisions is to encourage the development of longer distance traffic but no advantage has been taken of them except in one or two cases.

Under section 45 the board of trade is authorized, upon application, to examine derelict canals and order their abandonment or transfer to some body of persons or local authority who may agree to reopen them for navigation. This applies only to independent canals for the railways have been obliged even at a loss to maintain their canals in good working condition since the act of 1873.

The railway and canal traffic act of 1894 contains a clause which indirectly tends to prevent railways from cutting rates in competition with waterways.[1] Section 1 provides that when complaint is made that a rate which has been raised is unreasonable, the burden must lie upon the railroad company to show that it is reasonable. In cases where railways reduce their rates in competition with waterways, this provision would make it more difficult for them to raise them again after the water competition was eliminated.

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[1] 57 and 58 Vict., c. 54.

England is practically the only country which has attempted to regulate the affairs of water carriers. In Belgium, Germany, and France they have been left entirely free. In Russia it is stated that maximum rates for most of the waterways are fixed by the Government, and in Hungary the Government controls the charges of the Royal Hungarian Steamship Co. on the Danube, a line which it subsidizes.

The provisions in the railway and canal traffic acts of 1873 and 1888 intended to protect the canal companies against railway control apparently have had little salutary effect. The explanation generally given is that these laws came too late. One-third of the total canal mileage fell into the hands of the railway companies as early as 1845. Some 83 miles were converted into railways and about 425 miles were abandoned; and practically all the remaining canal companies were in a decadent and bankrupt condition before any important legislation intended to afford them protection was secured. Another reason is that the provisions of the law are not enforced. Notwithstanding the prohibition, the railways continue to charge excessive tolls on sections of canals which they own or control, and in other ways discourage the use of waterways by shippers. The railways no longer engage in severe rate cutting for the elimination of water competition. But this is not necessary, inasmuch as the cost of shipping by water on most of the canals in their present neglected and decadent condition is so high that they are no longer active competitors.

No serious attempt has yet been made in the United States to regulate the relations between the railways and waterways. The prevailing opinion at the time the interstate commerce act was passed in 1887 was that the waterways were the great regulators and cheapeners of railway rates, and for this reason should be hampered as little as possible by Federal regulation. The Cullom committee, appointed by Congress in 1885 to investigate the conditions of railroad transportation, considered the benefits to be derived from development and maintenance of the waterways, and reported as follows: [1]

> * * * The evidence before the committee accords with the experience of all nations in recognizing the water routes as the most effective cheapeners and regulators of railway charges. * * * Competition between railroads sooner or later leads to combination or consolidation, but neither can prevail to secure unreasonable rates in the face of direct competition with free natural or artificial water routes.

In accordance with this view, the act of 1887 imposed no restrictions upon water carriers except when they were operated in connection with some railroad for the continuous carriage of goods on joint rates. The only reason for subjecting them to this regulation was to guard against a possibility of their being used by some railroad as a means of discriminating or obtaining some undue advantage over a competitor. This intention was very well set forth by Senator Cullom in the course of the debate on this bill, when he said: [2]

> There is no provision in this bill that at all interferes with water transportation unless it is operated under some arrangement with a railroad company or common carrier by rail by which it can take advantage of any other railroad that has no water connection at all.

The idea of doing anything to protect water carriers against railway competition was little considered at that time. Although the railways

[1] Report of Cullom committee, p. 170. [2] Cong. Record, 49th Cong., 1st sess., May 10, 1886, p. 4310.

had already demonstrated their superiority over many of the canals in the eastern part of the country and also over some of the smaller streams, they had not as yet made serious inroads into the business of the larger rivers. The Mississippi and its tributaries were still in the heyday of their prosperity. The water route from Chicago to New York by the Great Lakes and the Erie Canal carried its maximum traffic during this period. In 1887 the Erie Canal carried 3,840,513 tons, a record which has never since been equalled. This water route exercised a potent influence upon the rail rates in trunk-line territory, and for a number of years had been continuously forcing them down. As pointed out by Mr. Albert Fink in his statement to the Windom committee in 1878, its influence upon railroad rates extended over a much wider area. It was felt even as far as the southeastern territory.

The only section in the law of 1887 which could have afforded any protection to water carriers against the direct competition of railways was section 4, generally known as the long and short haul clause, but as finally passed this clause prohibited railways from charging less for a longer than for a shorter haul only "under substantially similar circumstances and conditions." This greatly narrowed its application. In deciding what constituted a dissimilarity of circumstances and conditions, the Interstate Commerce Commission declared in its first important decision that actual water competition of controlling force was a sufficient reason for exempting the railroads from the meaning of this section.[1] The result of this interpretation of the law and subsequent court decisions was that where water competition existed, railways were free to cut rates to any extent they chose, regardless of their charges to intermediate points.

There were two changes made in section 4 by the act of 1910, which it is expected will afford some protection to water carriers against railway competition. The words "Under substantially similar circumstances and conditions" have been removed, and in their place has been substituted the following provision:

> That upon application to the Interstate Commerce Commission such common carrier may in special cases, after investigation, be authorized by the commission to charge less for longer than for shorter distances for the transportation of passengers or property; and the commission may from time to time prescribe the extent to which such designated common carrier may be relieved from the operation of this section.

The change was not made with the express intention of protecting water transportation, but to prevent rate discriminations, particularly in Rocky Mountain territory. The Interstate Commerce Commission has contended that this provision authorizes it to determine the amount of discrimination between the charges for longer and shorter hauls where such discrimination is allowed. In its decision in the intermountain rate case it divided the country into five districts and fixed the maximum rates which the railroads might make between each of these districts and the Pacific coast terminals. The Commerce Court, however, overruled the Interstate Commerce Commission, holding that where competition beyond the control of the railroads existed it was the duty of the commission, upon investigation, after complaint, to grant the railways exemption from this section to any extent not in violation of the other sections of the law. The

[1] In re L. & N. R. R. Co., I. C. C. Rep., vol. I, p. 31.

Commerce Court further held that to fix the exact discrimination which a railway could make in its rates for a longer haul would be to exercise a legislative power, and therefore would be unconstitutional. This case has been appealed to the Supreme Court, and its decision will determine finally the power of the Interstate Commerce Commission under section 4. If the Supreme Court upholds the Interstate Commerce Commission, it would doubtless have authority to prevent railways from unduly cutting rates when competing with water carriers, if it chose to exercise it for this purpose.

The act of 1910 also added a new clause to section 4, which reads as follows:

> Whenever a carrier by railroad shall, in competition with a water route or routes, reduce the rates on the carriage of any species of freight to or from competitive points, it shall not be permitted to increase such rates unless, after hearing by the Interstate Commerce Commission, it shall be found that such proposed increase rests upon conditions other than the elimination of water competition.

This is the first piece of legislation intended especially for the protection of water transportation in the United States. It is hoped that this provision will also tend to prevent railways from cutting rates in competition with the waterways. If strictly enforced, it will doubtless prove of some benefit, but it can not accomplish much, for the reason that the common practice of railways, now in competing with inland waterways is to keep their rates constantly at such a low figure that water transportation is not profitable. Cutting rates to drive out water competition and then raising them again, except when navigation is closed, is no longer a common practice, for by raising rates an inducement is offered to water carriers to reenter the field.

The tendency in the United States, as in England, has been to increase the power of the Government over water transportation. It was made necessary in England by the control which the railways had secured over the canal companies. In this country it has been due to the rapidly increasing control of railroads over boat lines, especially on the Great Lakes and in the coastwise trade. Where the railways and boat lines are operated under joint tariffs, the Interstate Commerce Commission has found it practically impossible to judge of the reasonableness of such rates without having a greater knowledge of the affairs of the connecting boat lines. Accordingly, since 1887 it has recommended on numerous occasions that the law be extended to apply to common carriers by water at least to the extent of giving them power to collect statistics and demand reports.[1]

During the spring of 1910, when it became evident to the Interstate Commerce Commission that their power over water carriers was not to be increased by the pending legislation, they apparently took the position that under sections 1 and 20 of the law they already had sufficient power to collect statistics and to require accounts from all water carriers prorating with railroads. On the 31st of May the commission entered an order prescribing a uniform method of bookkeeping for all water carriers which were making joint rates with railroads for the transportation of commodities in interstate commerce. On the 11th of June the commission entered another order, directing all such water carriers in the United States prorating with a railroad or railroads to make certain reports respecting their cor-

[1] Cf. third annual report, p. 433; fifth annual report, p. 9; eighth annual report, p. 79; thirteenth annual report, p. 63, fifteenth annual report, p. 59.

porate organization, financial condition, and other internal affairs. The Goodrich Transit Co. and the White Star Line, two independent companies operating on the Great Lakes, appealed from these orders of the commission, and in 1911 the Commerce Court enjoined their execution on the ground that the commission's authority extended only to the interstate business of water carriers which was exchanged with railways on through rates, but over port-to-port or intrastate traffic it had no authority. These cases were appealed to the Supreme Court, which, on April, 1, 1911, decided that the commission had authority to require from water carriers reports on all their business in order to enable it the better to carry out the purpose of the act. The court said:

Congress, in section 20, has authorized the commission to inquire as to the business which the carrier does and to require the keeping of uniform accounts, in order that the commission may know just how the business is carried on, with a view to regulating that which is confessedly within its power.

In one other particular the power of the Interstate Commerce Commission over water carriers has been increased. Section 15, as amended in 1906, gave the commission authority, after hearing on a complaint, to establish through routes and joint rates, "provided no reasonable or satisfactory through route existed," even when one of the connecting carriers was a water line. The commission in 1906, in the case of the Enterprise Transportation Co., operating on Long Island Sound, established a through route between that boat line and the Pennsylvania Railroad Co. for the transportation of fish from Jamestown, R. I., to Philadelphia.[1]

In 1910 section 15 was amended by striking out the words "provided no reasonable or satisfactory through route exists" and inserting the following:

Nor shall the commission have the right to establish any route, classification, rate, fare, or charge when the transportation is wholly by water, and any transportation by water affected by this act shall be subject to the laws and regulations applicable to transportation by water.

The intention of this added clause was doubtless to make it clear that the commission had no authority whatever over water carriers which did not prorate with a railroad, but over those which did enter into such arrangements the power of the commission was increased.

It is gradually coming to be realized in this country that the laissez-faire policy regarding water transportation is hardly more successful than when applied to other forms of business activity. The lack of proper regulation has materially aided the railways in crushing out or controlling water transportation and our rivers are no longer the great cheapeners and regulators of railway rates that they once were. Even on the Great Lakes the railways have secured such control over the transportation of higher classes of freight between New York and Chicago that they have been able to raise the rates, while on traffic which they do not control the rates have continually declined. Also in the coastwise traffic the railways have secured such complete control that there is no longer any active competition. Independent companies can not successfully compete. This situation has led to proposals for securing additional legislation. A provision which has attracted a good deal of attention is contained in the so-called Panama

[1] 12 I. C. C., 373.

bill.[1] It makes it unlawful for any railroad company to own, lease, operate, control, or have any interest whatsoever in any common carrier by water with which it competes for traffic. A recommendation of somewhat different tenor is made by the National Waterways ways Commission in its final report. It proposes to extend the power of the Interstate Commerce Commission over all water carriers owned or controlled by the railways and also over all independent companies operating on regular schedules between specified points so that they may not be used in a manner prejudicial to the public good. The merits of these two propositions will be discussed in the last chapter.[2] It may confidently be expected that in the near future legislation of some kind will be adopted.

THE INFLUENCE OF RATE SYSTEMS UPON WATER TRANSPORTATION.

The general scheme of rate making in different countries exercises an important influence upon the success of water transportation. The basis upon which rate schedules are constructed depends largely upon the extent to which railway activities are controlled. In most European countries the systems of railroad rates in vogue are much more favorable to the development of water-borne traffic than those found in the United States. In Germany and Belgium, where the railways are owned by the State, they are operated largely with a view to the promotion of national interests. In both countries rates are made upon a kilometric basis, tapering in most cases with the length of haul, and there is no departure from the distance principle because of water competition. Where railways and waterways compete, the boat lines adjust their rates from day to day according to the supply of traffic and demand for transportation, while the railway rates are fixed and not easily changed. Thus the waterways are free to cut rates to secure traffic, but the railways are not.

It is a well-known fact that the ton-mile cost of transportation by water decreases greatly with the length of haul. After a boat is once loaded, the expense of moving it where natural conditions are favorable does not increase in proportion to the distance traveled. Hence boat lines competing with railways whose rates are fixed exactly according to the length of haul or taper gradually have an advantage which increases with distance. The waterways of Germany enjoy a greater advantage in this respect than those of any other country, and this has been an important factor in the growth of long-distance water traffic. On the Prussian railways the freight is divided into nine classes based on speed, carload lots, and the value of commodities. For the higher classes the railway rates taper moderately with distance up to 500 kilometers, or 310 miles, after which they are on a fixed kilometric basis, as shown by the table following.[3]

[1] H. R. 21969, 62d Cong., 2d sess., sec. 11.
[2] Vide, p 578 infra.
[3] National Waterways Commission, Doc. No. 19, p. 11.

Normal tariff rates for higher classes.

Distance.	Not in carloads.					
	Fast freight.		General freight.		Special tariff for certain specified goods.	
	Rate per (metric) ton-kilometer.	Rate per (short) ton-mile.	Rate per (metric) ton-kilometer.	Rate per (short) ton-mile.	Rate per (metric) ton-kilometer.	Rate per (short) ton-mile.
	Pfgs.	*Cts.*	*Pfgs.*	*Cts.*	*Pfgs.*	*Cts.*
Less than 50 kilometers (31 miles)	22	7.6	11	3.8	....	....
51-200 kilometers (124 miles)	20	6.9	10	3.5	....	....
201-300 kilometers (186 miles)	18	6.2	9	3.1	....	....
301-400 kilometers (249 miles)	16	5.5	8	2.8	....	....
401-500 kilometers (311 miles)	14	4.8	7	2.4	....	....
Over 500 kilometers (311 miles)	12	4.2	6	2.1	....	....
For all distances	....	....	....	....	8	2.8

In five of the lower classes, which include the coarser freights best adapted to go by water, the rates are uniform, while in the sixth class, as shown in the following table, there is a slight reduction in the rates after 100 kilometers:

Normal tariff rates for lower classes.

Distance.	Carloads.						Special tariffs.					
	A1.		B.		A2.		I.		II.		III.	
	Pfgs.	*Cts.*	*Pfgs.*	*Cts.*	*Pfgs.*	*Cts.*	*Pfgs.*	*Cts.*	*Pfgs.*	*Cts.*	*Pfgs.*	*Cts.*
For all distances	6.7	2.3	6	2.1	5	1.7	4.5	1.6	3.5	1.2	....	....
1-100 kilometers (62.1 miles)	....	....	....	....	....	....	....	....	....	....	2.6	0.9
Over 100 kilometers	....	....	....	....	....	....	....	....	....	....	2.2	.76

On the other hand, the terminal charges, which are distinct from the charges for transportation, increase with the distance up to 100 kilometers, at which they remain fixed, regardless of the length of haul. For example, the terminal charges for fast freight increases from 20 to 38 pfennigs per one-tenth metric ton for distances from 1 to 100 kilometers, which is an increase of 2 pfennigs for each 10 kilometers. For all distances above 100 kilometers the charge is 40 pfennigs.

This advantage of the waterways in Germany is not so important as it might at first seem, because of the fact that there are in force a large number of exceptional rates, intended to enable German industrial centers or seaports to compete successfully with their rivals in foreign countries. These exceptional tariffs generally apply to the coarser, bulky commodities, such as are especially suited to go by water, and as a rule apply only to shipments in specified quantities. In 1906, 64 per cent of the total tonnage of the Prussian railroads was transported under exceptional rates, and in some of the other German States the proportion was nearly as great. There are in Prussia 27 classes of exceptional tariffs in force within the State, the purpose of which is to enable industries to

obtain cheap raw materials and to equalize the advantages of competing producers in a given market, and 31 classes of seaport exceptional tariffs intended especially to protect Hamburg and Bremen against the competition of Rotterdam and Antwerp, and also to enable home producers to reach the world's markets on favorable terms with foreign competitors. A further purpose is to divert traffic to the seaports which otherwise would be carried by the connecting railways of foreign countries.

All exceptional rates in force on the German railways are made on the same basis as the regular rates, the only difference being that the rate per ton-kilometer is considerably less and more often graduated for longer distances. For example, the regular rail rate on coal for distances from 1 to 100 kilometers is 2.6 pfennigs per ton, and for all distances over 100 kilometers 2.2 pfennigs per ton, with terminal charges in the first case varying from 60 to 90 pfennigs, and in the latter case amounting to 120 pfennigs. The great bulk of German coal traffic, however, is transported at exceptional rates in order to enable industries in all parts of the Empire to obtain cheap raw materials. The rate on most of this coal traffic, if carried in carload lots of not less than 10 tons, is 2.2 pfennigs per ton-kilometer for all distances up to 350 kilometers, and 1.4 pfennigs for all distances above this limit, with terminal charges of 70 pfennigs per ton.

As a rule the domestic exceptional rates are not detrimental to water transportation. Some of them are made to river ports in order to encourage the exchange of traffic between the waterways and railways. This is especially true in Bavaria, Baden, and some of the other German States, although there are a few instances of such rates in force in Prussia. On imports which compete with domestic products the regular rates are charged. These, as previously stated, are favorable to the waterways. There are a few exceptional import tariffs in force, but as a rule they do not apply to low-grade freights which the waterways carry.

Some of the exceptional export tariffs in Germany have undoubtedly diverted to the railways a considerable amount of traffic that would otherwise be transported by water. The low rates on coal from the Westphalian district, if intended for export through the port of Hamburg, serve to reduce the amount of coal traffic which would otherwise be exported to Holland and Belgium by means of the Rhine. In the same manner the rates on Silesian coal intended for export at Hamburg or Stettin are so low as to offer severe competition to the joint rail and water route via Kosel and the Oder. On shipments of 45 tons or more the rate is 5.1 mills per ton-mile plus a terminal charge of 14.28 cents per ton. These low rail rates are made for the purpose of enabling Silesian coal to reach these ports on equal terms with the coal from the Westphalian district, and especially that imported from England.

The rates in force on the State railway system of Belgium are constructed on a tapering kilometric basis, the rate per ton kilometer decreasing with the length of haul, according to a sliding scale, which usually changes with each 25 kilometers of distance.[1] For this reason Belgian rates are much less favorable to the success of the waterways than the German rates. This, however, is not so important in its

[1] For a good description of the Belgian rate system see L. G. McPherson, Transportation in Europe, p. 98.

effect upon waterway traffic as the fact that in many instances the average rail haul in Belgium is so short that there is no economy in shipping by water. This is particularly the case with the Belgian coal traffic, when intended for use within the country. As the table indicates, the great bulk of this coal is carried for a distance averaging less than 35 miles.[1]

Coal shipments on the Belgian State railways.

Kilometers.	Metric tons.	Kilometers.	Metric tons.
1- 10	2,192,306	141-150	83,664
11- 20	1,645,459	151-160	86,159
21- 30	1,193,369	161-170	85,530
31- 40	1,037,099	171-180	93,144
41- 50	922,089	181-190	18,025
51- 60	1,132,068	191-200	11,334
61- 70	731,599	201-210	8,336
71- 80	333,721	211-220	54,542
81- 90	283,272	221-230	8,976
91-100	354,095	231-240	71,622
101-110	559,997	241-250	113,769
111-120	211,707	251-260	8,658
121-130	159,985	261-270	35
131-140	82.769	270	0

As in Germany, there are some special and exceptional rates in force on the Belgian State roads which affect unfavorably the traffic of the waterways. These rates are mostly on export traffic to Antwerp in order to place home industries upon a more advantageous footing with their foreign competitors. There are fewer exceptional rates on imported commodities. In general, import business is conveyed at the regular rates so as to afford protection to home industries. For this reason the waterways convey a larger import than export traffic. This is especially true of coal. The rail rate on export coal to Antwerp in some cases is so low as to be practically prohibitive for the waterways. This is particularly the case with the coal from Liege to prevent it from going to Dutch or German ports. Hence most of the coal exported from Belgium by water goes to France by the inland-waterway system. The following table gives a comparison of the regular rates on coal and those contained in special export tariffs Nos. 1 and 2. In the case of special tariff No. 1 the minimum quantity accepted at the low rate is 11 tons, and in the case of tariff No. 2 it is 55 tons.[2]

[1] Annales des Travaux Publics de Belgique, 1908, p. 936.
[2] National Waterways Commission, Doc. No. 20, p. 15.

Comparative table of charges of special tariffs for exportation and those of the regular tariffs.

[Charges per ton (2,204 pounds).]

Distances.	Coal.				Coal, rough.			
	Special tariff No. 1 for exportation (shipments per 10 tons).		Regular tariff, fourth class of tariff No. 3.		Special tariff No. 2 for exportation (shipments per 50 tons).		Regular tariff No 2 for exportation (shipments per 50 tons).	
	Francs.	United States equivalent.	Francs.	United States equivalent.	Francs.	United States equivalent.	Francs.	United States equivalent.
50 kilometers (31 miles)	2.20	$0.42	3.00	$0.58	2.00	$0.39	3.00	$0.58
75 kilometers (46.6 miles)	2.20	.42	4.00	.72	2.00	.39	4.00	.72
100 kilometers (62.1 miles)	2.60	.50	4.50	.87	2.00	.39	4.50	.87
125 kilometers (77.6 miles)	3.25	.63	4.75	.92	2.50	.48	4.75	.92
150 kilometers (93.2 miles)	3.90	.75	5.00	.96	3.00	.58	5.00	.96
175 kilometers (108.7 miles)	4.55	.88	5.25	1.01	3.50	.67	5.25	1.01
200 kilometers (124.2 miles)	5.00	.96	5.50	1.06	4.00	.72	5.50	1.06
250 kilometers (155.3 miles)	5.50	1.06	6.00	1.16	5.00	.96	6.00	1.16
275 kilometers (170.8 miles)	5.75	1.11	6.25	1.21	5.50	1.06	6.25	1.21
300 kilometers (186.4 miles)	6.00	1.16	6.50	1.25	6.00	1.16	6.50	1.25
325 kiolmeters (201.9 mlles)	6.50	1.25	6.75	1.30	6.50	1.25	6.75	1.30
350 kilometers (217.4 miles)	7.00	13.5	7.00	1.35	7.00	1.35	7.00	1.35

The French system of railway rates is also based upon the kilometric principle, the ton kilometer rate decreasing with distance at each 100 kilometers. The decrease is quite marked as the length of haul increases, but this fact has no injurious effect upon water transportation as long as the general principle of maintaining railway rates 20 per cent higher than competing water rates is enforced. The waterways enjoy the same advantage on import traffic that they do in Belgium and Germany, the control of the Government being sufficient to keep up the railway rates for protective purposes. There are a large number of special rates in force on the French railways, some of which are detrimental to water transportation. These are found mostly, as in Germany and Belgium, on export traffic to the seaports, where national considerations outweigh the importance of protecting the waterways. There are also some domestic tariffs in force in France which are the same from a producing center to a considerable number of different localities, regardless of the difference in the length of haul. This is particularly true of domestic coal, to enable it to compete with English coal in the home markets. These special rates are only accorded to shippers who agree to ship certain quantities and to comply with certain conditions favorable to the railways.

The systems of railway rates that have developed in the United States are all unfavorable to the growth of water transportation. This is due to the fact that during their formative period they were practically free from all regulation and based almost entirely upon the principle of charging what the traffic will bear. The characteristic feature of American railroad rates is that local rates are high, while through rates are relatively low. The distance principle, which is the basis of all foreign rate systems, is often violated in long-distance traffic, while local or intrastate rates, which are usually subject to the control of State railroad commissions, follow it more

closely. In almost all cases rates taper rapidly with the length of haul. Wherever water, rail, or market competition exists, railroad rates are adjusted to meet it, and on interstate business the freedom of the railways in changing their rates has as yet been little restricted. Consequently we often find rates decreasing instead of increasing with the length of haul. This is especially true with rates which are in competition with coastwise water competition. On transcontinental shipments, for instance, it has been customary to charge the same rate from New York to San Francisco as from Chicago, St. Louis, and other Mississippi River ports, while the charges to Reno, Nev., to Denver, Colo, and other intermediate Rocky Mountain points are higher than to the Pacific coast terminals, although the haul may be several hundred miles shorter. The New York-San Francisco rate is forced by water competition, while St. Louis and Chicago are granted the same rates as New York in order to allow them to reach the Pacific coast cities on equal terms with New York.

Another good illustration of the effects of coastwise water competition is found in the rate from New York and North Atlantic ports to New Orleans or Mobile. The first-class rate from New York to Atlanta is only 14 cents higher than to Charlotte, N. C., an intermediate point 218 miles nearer, and the rate to Mobile and New Orleans is almost the same as the rate to Atlanta. Thus in order to meet water competition at the farther point, freight is hauled for 1,372 miles at a rate only a few cents higher than for 608 miles.

The basing point system of rate making in the southeastern territory is the direct outgrowth of conditions resulting largely from water competition. This territory is surrounded on three sides by water and penetrated by a number of navigable streams. Before the advent of the railways these rivers furnished the only outlet from the interior to the seacoast. The packet boats connected with the coastwise steamers and afforded communication with the North Atlantic ports. A number of important towns grew up at the head of navigation on these streams, and when the railroads from the North reached them they received low rates because of water competition. After railroads were built parallel to these rivers connecting the seaports with the interior, river transportation declined, but these towns continued to receive low rates. The combination water and rail rates from the north to any point in this territory, whether located on the river or not, determine the rates that the all-rail lines can charge. In the adjustment that has resulted these favored cities have been granted low rates, while the surrounding towns not so favored usually pay a rate which is higher by an amount equal to the local rate to the nearest basing point. In these rate adjustments which have prevailed for many years the all-rail lines do not make their charges equal to the rail-and-water rates, but usually a certain differential above, varying with the different classes and at different centers.

Along the navigable rivers, except where prohibited by State laws, it has always been the custom of the railroads to charge lower rates to river than to nonriver points. The preliminary report of the Inland Waterways Commission gives a large number of examples of such rates along the Ohio, Tennessee and Mississippi Rivers. Railway rates along the Mississippi Fiver appear to have been especially

devised to prevent the growth of water competition. The rate from St. Louis to New Orleans, a distance of 700 miles, is the same as to Greenville, an intermediate point 250 miles nearer. All points between Greenville and New Orleans are grouped together and given the same rate. Likewise on the north-bound traffic the rail rates from New Orleans to all places between Natchez (214 miles) and Memphis (396 miles) are the same. The New Orleans rate is forced by various circumstances, while the river competition holds down the rates of the cities above, which otherwise would be higher than the New Orleans rate.

The first half of the table below shows the rail rates between St. Louis and New Orleans on a number of commodities which would naturally be transported by water. The second half shows the rates from New Orleans to Memphis on the northbound traffic. As a rule the rail rates on low-grade commodities are relatively lower than on the higher classes of freight which are less inclined to go by water.[1]

	Distance (miles).	Lumber and wood.	Sand and gravel.	Building stone.	Grain.	Flour.	Provisions.
From St. Louis to—							
Memphis	311	$3.00	$1.60	$2.80	$2.40	$2.29	$4.00
Greenville, Miss	448	4.00	3.00	5.00	2.40	3.60	6.00
Vicksburg, Miss	531	4.00	3.00	5.00	2.40	3.60	6.00
Natchez, Miss	614	4.00	3.00	5.00	2.40	3.60	6.00
Baton Rouge, La	677	4.00	3.00	5.00	2.40	3.60	6.00
New Orleans, La	699	4.00	3.00	5.00	2.40	3.60	6.00
From New Orleans to—							
Baton Rouge, La	89	....	1.40	1.60	1.60	1.60	2.40
Natchez, Miss	214	....	1.60	2.40	2.40	2.40	3.00
Vicksburg, Miss	227	....	1.60	2.40	2.40	2.40	3.00
Greenville, Miss	310	....	1.60	2.40	2.40	2.40	3.00
Memphis	396	....	1.60	2.40	2.40	2.40	3.00

With such rates in force through shipments by river have become unprofitable. They were discontinued between St. Louis and New Orleans in 1903, but a company has recently been formed at St. Louis which intends to reestablish this service. The entire distance may still be covered by boat by making three or four transfers. But in such a case the sum of the different water rates would be considerably in excess of the through railroad rate. On the northbound trade no packet line has been able to maintain a schedule between New Orleans and Memphis for several years.

Several kinds of commodity rates have been developed by the railroads which, because of their convenience to shippers, have been very unfavorable to water transportation. The decline of grain shipments on the Mississippi River has been due as much to the milling-in-transit rates as to any other factor, especially in the case of the traffic not originating directly on the river. A through rail rate and through bill of lading to destination, with the privilege of stoppage at some point for storage or for milling may be obtained at the point of origin. If this traffic were intended for shipment by river, it would pay a high local rate from the grain fields to St. Louis or some other river port. At this point there would be a separate charge for milling or elevator services. In addition there would be transfer, drayage, and insurance

[1] H. Doc. No. 50, 61st Cong., 1st sess., p. 368.

charges to pay, all of which reduce the advantages of shipping by the water route. The cost and inconvenience of shipping grain in this way compared with paying at one time all the charges and placing the consignment in the hands of one responsible party for the whole shipment has resulted in diverting practically the whole grain traffic from the Mississippi River to the competing railroads. Another factor in this connection is that a considerable share of the wheat which formerly went to New Orleans for export is now milled and distributed from St. Louis in various directions for domestic use.

In the same manner the through rates, including the privilege of compressing cotton in transit, have greatly reduced the river traffic in this commodity. A through bill of lading and a through rate from the cotton fields to New England or Liverpool can be obtained by the shipper, including all charges for compressing en route. Ordinarily this is much cheaper and more convenient than to send the cotton down the river to some point where it must be unloaded and hauled to a compress and back again to the river. Furthermore, insurance rates on cotton shipped by river are very high, owing to its great value. From Vicksburg to New Orleans the rate is 20 cents per bale. Such freight is rarely insured when sent by rail, inasmuch as the railroad is liable for damages.

As a result of railway competition scarcely any cotton has been shipped from Memphis to New Orleans by river since the year 1895. In a few cases, where plantations are located directly on a river and not readily accessible to a railroad, it has been found cheaper and more convenient to ship cotton by river to some center such as Memphis or New Orleans where it is compressed and forwarded by rail. This is true only where shipments are made for comparatively short distances.

The commodity rates on grain from the West to North Atlantic seaports are so constructed as to divert traffic from the Great Lakes and Erie Canal. Wheat may be brought from Minnesota or the Dakotas to Chicago and there stored or milled, and then sent on to New York under the original bill of lading at a rate which is much lower than the regular rate. If the traffic is intended for export, the rate is still lower. Where grain is brought to a lake port for transshipment to lake steamer, the rail charge for the shorter haul is higher, relatively, and to it must be added transfer, insurance, and other charges.

An important source of traffic for European waterways, as we have seen, is the transportation of imports and exports between the interior and the different seaports. The development of such traffic in the United States is practically impossible because of the railway rates on this business. As a rule they are much lower than the domestic rates for the same commodities. Since the decision of the Supreme Court in the import rate case in 1895, the Interstate Commerce Commission has exercised no control over the division of import and export rates between the railways and the connecting ocean carriers and they have been free to reduce their rates to any point necessary to secure the traffic.[1]

In Europe the import traffic forms a much larger proportion of the business of the waterways than export traffic, one reason being that it

[1] 162 U. S., 197.

consists to a larger extent of raw products suited to be conveyed by water. In the United States the situation is exactly the reverse. Exports greatly exceed imports and grain, cotton and other raw products still form a large proportion of the export business, although the amount of manufactured products exported is rapidly increasing. In former days the Mississippi, Hudson, and other rivers played an important part in bringing these products from the interior to the seaports for transshipment to ocean-going vessels, but the rail rates now in force have diverted practically all this business to the railways. The export and import rates from New Orleans to points in the Mississippi Valley are much lower than the domestic rates. These rates have been forced by the competition of the trunk line railways to the Atlantic seaports, and also by the competition of the railroads terminating at Galveston and Mobile.

THE DEVELOPMENT OF TRANSFER TRAFFIC.

Under ordinary circumstances the development of a large commerce on a waterway system is only possible where there is a ready exchange of traffic between the railways and water lines. It rarely happens that the sources of supply for the business of a waterway and the cities or factories consuming the commodities it carries are both so situated that an intermediate rail haul is not necessary. Usually coal mines, quarries, ore beds, and other sources of traffic are not located directly on navigable lakes or streams, but often can be connected with them by a comparatively short rail haul so that their products may be transported by water. A rail-and-water route is most feasible where a short rail haul can be joined with a relatively long water haul. The cost and inconvenience of transferring freight can be greatly lessened where physical connection between the railway and the waterway is established and tipples, cranes, or other devices for accomplishing the transfer as economically and as rapidly as possible are employed.

It is interesting to note that the waterways on which there exists the largest commerce enjoy this exchange of traffic between boat lines and railways. On the Rhine, in Germany, this is especially the case. More than half of the total tonnage of this river is carried on combination rail and water routes. Practically all the enormous coal tonnage shipped from Duisburg-Ruhrort, amounting in 1909 to 12,352,631 tons, is brought there by railways from the coal mines and transshipped to river boats. Likewise a considerable portion of the grain and iron ore received at Duisburg-Ruhrort is transshipped to the railways for distribution through the Westphalian district. All along the Rhine are located important transfer stations, where terminals have been especially constructed for exchanging freight between the railways and boat lines. Of these, Mannheim is the most important. For a long time this city was the head of navigation on the Rhine, and is still the upper terminus for larger river boats. Mannheim has always been a distributing center for a large hinterland. More than a third of the coal received by Rhine boats is transshipped to the railways and distributed in various directions. Mannheim also receives by river petroleum brought in specially constructed tank boats, and also grain in large quantities, a considerable share of which

is intended for distribution inland. The following table shows the amount of coal and grain transshipped at a number of Rhine ports:[1]

Ports.	Total receipts.	Coal reived.	Coal transshipped to rail.	Grain received.	Grain transshipped.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Mannheim	4,758,917	2,090,011	876,472	947,085	131,072
Ludwigshafen	1,724,191	769,709	188,029	385,615	103,648
Rheinau	1,569,144	1,414,602	459,560	....	....
Gustavsburg	1,057,004	932,364	802,401	....	....

The two most important transfer ports on the Oder are Kosel and Breslau. At these ports large quantities of Silesian coal are brought by rail and transferred to river barges. In fact, the transfer harbor at Kosel was construced only a few years ago by Prussia especially to facilitate this coal traffic. The local traffic at this port amounts to very little. In 1909 the total shipments by the Oder at Kosel were 1,477,312 tons, of which 1,350,051 tons consisted of coal. All but 5,000 tons of this amount was brought by rail and transshipped. On the upper Elbe, in Austria, there is a large exchange of traffic between the river boats and the State railways, which have built transfer terminals at their own expense. More than 1,000,000 tons of Bohemian lignite are brought to the river ports and transshipped to barges for distribution to German cities each year. At Magdeburg, on the Elbe, in 1909, 156,318 tons of grain were transshipped from boat to rail and 203,767 tons of potash from rail to boat. At Schönebeck, on the Elbe, 283,616 tons of potash were also transshipped from rail to boat.

There are several reasons for this cooperation of railways and waterways in the development of transfer traffic in Germany. In the first place, each of the German States has its own system of railways, among which there has always existed considerable rivalry. The competition between the Prussian State railways and those of Saxony and Baden has often been quite severe. It is stated that Saxony has at times resorted to the practice of giving rebates to shippers in order to divert traffic from the Prussian railways. This rivalry between the State railways is shown especially by the construction of transfer ports along the Rhine. Mannheim is the terminus of the Baden State railways, and across the river the Bavarian State lines have constructed a rival port at Ludwigshafen. After the Rhine was deepened from Mannheim to Strassburg, the latter city also became an important transfer port between the boat lines and the State railways of Alsace-Lorraine, but the railways of Baden at once constructed a rival transfer port at Kehl just across the river. In order to make their respective ports the equal of others, the different Rhine States have often contributed large sums for their improvement and equipped them with the best loading and unloading appliances.

A second reason for the growth of transfer traffic in Germany is due to the Government's policy in the management of the state railways. Since the time of Bismarck the Prussian roads have been an important source of revenue for the State. In recent years they have

[1] Statistik des Deutschen Reichs. Band 235 I, 1909, Teil II, p. VIII.

yielded a return of approximately 7 per cent on the investment. In order to preserve this revenue, the State encourages the shipment by water of coarse, bulky freights, such as coal, whenever the waterway affords the cheaper route. This leaves the railways free to devote their equipment to the transportation of more profitable business. Furthermore, Prussia is the only State whose railways compete extensively with the Rhine. In most of the other Rhine States the railways form extensions of the river and it is to their interest to promote the development of transfer traffic. In order to do this the different State railways have in some cases put in force to the river ports special transship tariffs (Umschlagstariffs). These were granted by the Baden railways to Mannheim in 1903, and exist at a number of ports along the Rhine, Elbe, and Oder.

There are some cases in Germany where two or more transshipments between rail or water lines occur, especially on international traffic. A consignment may be sent down the Elbe by river barge, transferred to a railroad, and brought to some Rhine port, and there transferred again to river barge for shipment to Rotterdam or Antwerp. More frequently there are two short rail hauls with a long river haul intermediate. This happens on all the coal transshipped to river barges at Duisburg-Ruhrort, and again transshipped to rail at Mannheim or some of the upper Rhine transfer ports for distribution inland.

In small countries, such as Holland or Belgium, where the waterway systems are quite complete in themselves and the length of haul is comparatively short, there is little opportunity or necessity for the development of transfer traffic between railways and waterways. To make such transfer profitable it is usually necessary to join a long water haul with a short rail haul and the former does not exist. Even the coal brought into Belgium by Rhine boats from Duisburg-Ruhrort is used by factories and other consumers directly along the waterways. Practically none of it is transferred to the railways.

There exists a large amount of transfer traffic in Russia, especially along the Volga. This is due to the fact that the railways do not parallel the river throughout its length, and hence find it to their advantage to use it as a feeder to their lines. A very interesting case of cooperation between railways and waterways is also found on the Danube in Hungary between the State railways and a Government subsidized boat line. In 1894 the State created the Royal Hungarian Company of River and Maritime Navigation, for a period of 20 years, with a capitalization of $400,000. During the life of the contract the State grants the company an annual subvention of $160,000, and in case the revenue should not suffice to pay the shareholders a dividend of 5 per cent the subvention is increased by $20,000. The company, on its part, agrees to furnish a prescribed passenger and freight service, with regular schedules and at rates which are under the control of the Government, and may be reduced, if the occasion demands, to the actual cost of service rendered. The company is required to make agreements with the State railway system for the ready exchange of traffic. This is practically the only case in Europe where prorating arrangements exist between the railways and inland waterways. In all other cases the rail and water rates are distinct.

While France has been able to protect her waterways against the direct competition of the railways, she has never succeeded in compelling the railways to establish physical connection with water lines

and to cooperate with them in the development of exchange traffic. For this reason the business of the waterways, aside from that exchanged with the seaports, has been limited largely to such traffic as is accessible to them. In 1900 only 750,000 metric tons were transshipped from railways to waterways, or vice versa. More than half of this exchange traffic was transshipped at four ports and the remaining half was divided among 26 different ports. During recent years there has been little increase in the amount of exchange traffic. At present it averages about 800,000 tons, or less than one-fortieth of the total tonnage of the inland waterways. Of this amount more than 50 per cent is transshipped at Roanne and much of the remainder is carried on private industrial roads owned by large manufacturing or mining interests.

The amalgamation of the railways into a few systems, each having a complete monopoly in its part of the country, has removed the self-interest which the railways might otherwise have for encouraging transfer traffic, and the lack of proper legislation makes it very difficult to compel them to connect with the water terminals. Article No. 62 of the Cahier des Charges provides that a railroad company must make connections with any proprietor of a mine or factory who is willing to submit to prescribed conditions and shall demand a branch line. In case of failure to connect, the Government shall decide upon the justice of the demand. No provision is made for establishing branch lines to waterway terminals. This is left optional with the railways.

When the Cahier des Charges was enacted during the years 1857–59, the necessity of safeguarding the waterways was not thought of. It was a common practice at that time for the railways to connect with waterways and to use them as feeders to their lines. They often established transshipment ports and in other ways sought to facilitate the growth of exchange traffic. After amalgamation had proceeded further this cooperation with the waterways for the transfer of traffic was no longer to the advantage of the railways and they proceeded by various practices to discourage it. Until prohibited, they charged high rates on freight destined to or received from water terminals and exacted exorbitant charges for the use of terminal facilities. They also refused to make adequate connections, and the Government has been unable to compel them to do so. Concessions granted to new railroad companies in recent years impose upon them the obligation of making suitable connections with river and canal ports, but the problem of forcing the older lines to establish such connections has not been satisfactorily solved.

Some interesting examples are given by M. Leon of the struggle which different cities have had with the railways to obtain proper connection with the waterway terminals.[1] It was 18 years before the P. L. M. road was compelled to connect with the waterway at Dôle. At the port of Pouilly-en-Auxois the connection decided upon in 1882 has been indefinitely postponed. The city of Roanne struggled with the P. L. M. railroad for 31 years. It took 9 years to get a sidetrack built connecting the waterway with the main station. Then the railroad charges for hauling freight from this branch line were twice what it would cost by truck. It took a

[1] Paul Leon, Fleuves, Canaux, Chemins de Fer, p. 106.

number of years to get this rate reduced. Then the traffic increased so rapidly that a new terminal was necessary and the construction of this took a long time. The railroad company failed to provide a switch engine to get the cars alongside the boats, although it delivered them at the terminal. This forced the shippers to incur the expense of getting their cars into place as best they could. Furthermore, the railroad company imposed a demurrage tax of 50 centimes an hour if the cars were not loaded or unloaded within four hours. Adequate facilities for transferring the freight were not obtained until 1897. Since then the city has become the most important transfer point in France.

An attempt to remedy this defect in the existing laws relating to terminal connections was made in 1908. An act was passed imposing upon the railways the obligation of establishing proper physical connections with the transfer ports established by the State, but granting them as compensation a right of indemnity as regards charges and loss of receipts which they might incur. This act has not succeeded in remedying the difficulties which resulted from the weakness of the original law. The indemnity which the railroads could claim if they were forced to establish connections at a port would in most cases be so considerable that the Government is reluctant to enforce the law.

In the United States the exchange of traffie between the railways and water carriers is especially noticeable along the Great Lakes and in the coastwise trade. Formerly it was also a common practice along the Ohio, Mississippi, and other rivers. Shipments could be made from the Pittsburgh territory by river and rail to Atlanta, Chattanooga, Birmingham, Selma, and a large number of southern and western points.[1] These prorating arrangements were withdrawn about 1900, owing to the expansion of the railway net and the greater community of interest which has prevailed among the railways in recent years.

On the Great Lakes by far the greater part of the traffic has two short rail hauls with one long intermediate water haul. Practically all of the 41,000,000 tons of iron ore shipped annually from the five Lake Superior ports is brought from the ore beds to the lake front by rail and all but a few million tons is transshipped to rail at the lake Erie ports for distribution in the Mahoning Valley and Pittsburgh districts. Likewise the coal transported on the Great Lakes is brought from the mines in Pennsylvania and West Virginia by rail to the Lake Erie ports and transshipped to lake vessels. A considerable proportion of this traffic is again transshipped to rail at the ports where it is received. Most of the grain traffic on the Great Lakes also has a rail haul from the grain fields to the lake front, and another haul from Buffalo and other Lake Erie ports to New York City or other point of destination.

The Great Lake ports where the largest tonnage is handled have been equipped with loading and unloading machinery superior to anything found in European ports. The record for loading coal in 1911 was 10,057 tons in 6 hours and 35 minutes, or an average of 1,530 tons per hour.[2] As a rule iron ore is loaded much more rapidly than coal. On September 8, 1911, 9,457 tons of iron ore were loaded at Superior in 25 minutes, or at the rate of 378 tons per minute. The

[1] Preliminary Report of the Inland Waterways Commission, p. 331.
[2] Annual Report Lake Carriers' Association, 1911, pp. 163, 164.

process of unloading from lake steamers requires somewhat more time, but with the installations now being used the time has been much shortened. The record for unloading iron ore in 1911 was made at Ashtabula, when a cargo of 10,324 gross tons was unloaded in 4 hours 6 minutes by four 15-ton Hulett electric machines. This was at the rate of 637 tons per hour for each machine.

The enormous iron ore and coal traffic exchanged between the railways and lake vessels is not as a rule carried on prorating arrangements. Much of it is carried by steamship lines owned by industrial corporations which are not common carriers. Except where contracts are in force, the lake rate varies from day to day, according to the demand for shipping facilities. On grain from Chicago and other lake ports to New York a rail-and-water rate is generally quoted which is a few cents lower than the all-rail rate. Almost all the package freight business on the Great Lakes is carried by railway-owned steamship lines operating in connection with the railways on through rates. Some of the independent companies also prorate with the railways on a small proportion of their business.

Along the Atlantic coast there is a large amount of transfer traffic between the railways and coastwise vessels, especially between the steamship lines plying between New York and southern ports and the railways connecting these points with the interior. Most of this traffic is carried on through rates and the division of the rate between the carriers is made according to a plan which has long been in force. Three nautical miles are considered equivalent to one mile by rail.

The experience of all countries seems to indicate that railways will cooperate with waterways for the development of transfer traffic only where there is an advantage in doing so. Where railways are owned and operated by private companies, and the different companies are working in harmony, traffic will be transferred from one rail line to another in preference to being turned over to a water route. In Europe the railways do not own or attempt to control the water carriers with which they exchange traffic, but in the United States cooperation between the two agencies of transportation is most successful where the railways own or control the connecting water carriers. Where a boat line is owned by a railroad it is very difficult, as a rule, for independent companies to compete with it, inasmuch as the railway-owned boat line enjoying prorating arrangements generally has a monopoly of all the transfer traffic and is also able to compete on equal terms for the local, or port-to-port, traffic. There are many instances in theUnited States where independent companies not enjoying prorating arrangements with railways have been driven out of business. This has led to the proposal to clothe the Interstate Commerce Commission with greater powers over the activities of water carriers, so that the advantage which a railway has by reason of its ownership of a boat line may not be used to eliminate water competition and to raise water rates.

VI.

Comparative Rail and Water Rates.

Under normal conditions the charges of boat lines in competition with railways must be considerably less than rail rates in order to offset the natural disadvantages of the waterways and to induce

traffic to move by the water route. As a rule the railway offers superior service and greater speed, for which shippers are willing to pay a somewhat higher rate. In addition to the mere charge for transportation, water shipments must also pay transfer charges, insurance rates, and sometimes drayage charges. The amount of difference between rail and water rates necessary to give the waterways a fair share of the traffic varies in each case according to the circumstances. Ordinarily a difference of at least 20 per cent is necessary. In some cases on the Mississippi hull and cargo insurance alone would require a difference of 33⅓ per cent. There are instances, however, both in the United States and abroad, where the waterways secure a large traffic at rates as high or even higher than those charged by the competing railway. Such a situation usually occurs during periods of congestion or around large cities, when the waterway is more certain to afford prompt delivery than the railway.

The flourishing condition of the more important foreign waterways may be readily understood if the rail and water rates between different points are compared. The wider the margin, the greater is the advantage of the water route. Where, as in Germany, the rail rates are fixed with little regard to water competition, and the waterways are, for the most part, toll-free rivers, accommodating boats of from 400 to 2,000 tons capacity, the difference between rail and water rates often becomes very considerable. In Belgium, although the rail rates are fixed in the same manner as in Germany, the margin in favor of the waterways is somewhat less, owing to the fact that they are not so large, and on all except tidal streams tolls are charged, the returns from which defray a large part of the annual cost of maintenance. In France, although waterways are for the most part toll free, the difference between rail and water rates is usually not far from 20 per cent, the average differential fixed by the Government for the protection of the waterways. This is due to the fact that with the exception of the Seine the waterway system consists of canals or of small canalized rivers which accommodate boats of only 300 tons capacity. In countries like the United States, where no general policy for the protection of waterways has been adopted, there is ordinarily little difference between the rail and water charges. The railway rates are adjusted with a view to meeting water competition and sufficient reduction in rates is made to get the business. The differential in favor of the waterway is usually larger for the higher classes of freight than for the lower classes on which competition is most severe.

The greatest difference between rail and water rates in Europe is found on the Rhine and Elbe in Germany, especially on such commodities as coal, cereals, iron ore and sugar. The average charge for the transportation of coal on the Rhine from Ruhrort to Mannheim, a distance of about 220 miles by water, for the nine-year period 1901–1909, was 27.6 cents per metric ton. The lowest charge recorded during this period was 13.1 cents, which was made on a few consignments in 1908, and the highest charge was 58.8 cents, which was reached in the same year. The average yearly rate on this coal traffic was lowest in 1909, when it reached 18.3 cents per metric ton. This was due to a large increase in the number of boats competing for the traffic, which more than offset the considerable increase in the traffic itself.

The following table shows the average rates recorded for carrying coal during the last decade from the mouth of the Ruhr to Mannheim:[1]

Year.	Marks.	Cents.	Year.	Marks.	Cents.
	Per ton.	*Per ton.*		*Per ton.*	*Per ton.*
1901	1.05	24.9	1906	1.45	34.5
1902	1.00	23.8	1907	1.61	38.3
1903	1.18	28.1	1908	1.10	26.1
1904	1.23	29.2	1909	.77	18.3
1905	1.08	25.7			

Under the exceptional tariffs in force, the rail charge for coal in carload lots of not less than 10 tons from the Westphalian district to all parts of the German Empire is 8.4 mills per metric ton-mile for all distances up to 350 kilometers (217.5 miles), plus a terminal charge of 16⅔ cents per ton. This would make the rail charge from Gelsenkirchen, where the traffic originates, to Mannheim, a distance of 220 miles, about $2.02 per metric ton. But since the coal shipped by river at Duisburg is brought by rail from the mines, the rail charge and transfer charges should be added to the water rate in order to make the comparison correct. These extra charges amount to about 43 cents per ton. But even after they are added, the total charge by the rail and water route averages about 70 cents, as compared with $2.02 by rail.

The following table gives a comparison of rail and water rates for coal on the Rhine. Since on this traffic, as just explained, the all-rail route directly from the mines competes with the rail-and-water route, the actual differential in favor of the river can be more correctly ascertained if the rail rates are increased by about 14 cents per ton to offset the greater distance that the mines are from the points of destination, and the water rates by 43 cents to cover the rail haul from the mines to Duisburg and transfer charges.[2]

Terminals.	Distances.		Rate.	
	Rail.	Water.	Rail.	Water.
	Miles.	*Miles.*	*Per ton.*	*Per ton.*
Ruhrort to Mannheim	202.45	220.45	$1.88	$0.409
Ruhrort to Strassburg	267.65	301.81	2.26	.726
Ruhrort to Frankfort on the Main	176.34	195.62	1.64	.474

The difference between water and rail rates on imported cereals from the Rhine or Elbe seaports to the inland cities of Germany is also very considerable, due to the reasons already given—that the transshipment from ocean-going vessel to river barge is much cheaper than to freight cars; and also to the Government's policy of maintaining the regular rates on imported grains for the protection of domestic agrarians. On the Rhine the average grain rate from Rotterdam to Mannheim, a distance of 298 miles by rail and 354 miles by water, for the period from 1901 to 1905, was 72 cents per metric ton, while the rail

[1] Annual Report of the Central Rhine Commission, 1909.
[2] Compiled from data collected by the National Waterways Commission.

charge was more than $4. The following table gives a comparison between rail and water rates for the shipment of grain from Rotterdam to Mannheim, Strassburg, and Frankfort.

Terminals.	Distances.		Rate.	
	Rail.	Water.	Rail.	Water.
	Miles.	*Miles.*	*Per ton.*	*Per ton.*
Rotterdam to Mannheim	298.08	353.97	$5.81	$0.626
Rotterdam to Strassburg	362.66	435.32	5.71	1.102
Rotterdam to Frankfort on the Main	282.56	330.37	4.36	.764

On the Elbe the differential in favor of the water route for imported commodities is also very large. From Hamburg to Magdeburg, a distance of 156 miles by rail and 181 miles by water, the water rate in 1909 for imported cereals was 67 cents per metric ton, while the rail charge was $2.97. The following tables give the high, low and average water rates from Hamburg to Berlin on imported coal and grain for the period 1903–1907.[1] The rail rates on these commodities are anywhere from two to four times as high.

I.—*Coal rates from Hamburg to Berlin by water.*

Year.	High.	Low.	Average.
	Per ton.	*Per ton.*	*Per ton.*
1903	$0.95	$0.48	$0.64
1904	1.85	.48	.93
1905	.95	.57	.73
1906	1.19	.48	.72
1907	1.19	.57	.79

Where coal is sent from Hamburg to Berlin by rail special tariff No. III applies and the rail rate, including terminal charges, is $1.69 per ton, or more than twice the average water rate.

II.—*Grain rates from Hamburg to Berlin by water.*

Year.	High.	Low.	Average.
	Per ton.	*Per ton.*	*Per ton.*
1903	$0.95	$0.52	$0.67
1904	2.26	.48	1.23
1905	1.00	.59	.79
1906	1.43	.55	.81
1907	1.48	.67	.91

On rail shipments of grain from Hamburg to Berlin special tariff No. I applies, and the rail rate, including terminal charges, is $3.28 per ton, or nearly four times the average water rate.

The following tables give a comparison of rail and water rates for different commodities transported between Hamburg and several

[1] Paul Goehts,, Berlin als Binnenschiffahrtsplatz in Staats- und Social-Wissenschaftliche Forschungen, Hft. 147, pp. 147, 167.

interior cities. They were submitted to the National Waterways Commission by the consul at Hamburg in the summer of 1909. Since the distance by water is always somewhat greater than the distance by rail, a comparison of rail and water ton-mile statistics is misleading. Accordingly, in the last column, the ton-mile water rates are computed for rail distances. This plan is followed wherever in this paper ton-mile statistics are compared:

HAMBURG-MAGDEBURG.

Article.	Rail (252 kilometers, or 156 miles).			Water (292 kilometers, or 181 miles).			Per ton-mile, rail distance.
	Per ton.		Per ton-mile.	Per ton.		Per ton-mile.	
	Marks.		*Cents.*	*Marks.*		*Cents.*	*Cents.*
Sugar	16.30	$3.88	2.49	2.80	$0.67	0.37	0.43
Salt	6.70	1.59	1.02	2.80	.67	.37	.43
Grain	12.50	2.97	.80	2.80	.67	.37	.43
Coal	6.30	1.50	.96	2.70	.64	.35	.41
Iron	10.00	2.38	1.53	3.00	.71	.39	.45
Zinc and lead	12.50	2.97	.80	3.00	.71	.39	.45
Phosphate	6.20	1.48	.95	2.80	.67	.37	.43
Mineral oils	12.50	2.97	.80	3.00	.71	.39	.45
General merchandise	27.20	6.47	4.13	4.00	.95	.53	.61

HAMBURG-BERLIN.

Articles.	Rail (280 kilometers, or 174 miles).			Water (375 kilometers, or 233 miles).			Per ton-mile, rail distance.
	Per ton.		Per ton-mile.	Per ton.		Per ton-mile.	
	Marks.		*Cents.*	*Marks.*		*Cents.*	*Cents.*
Sugar	18.00	$4.28	2.46	3.20	$0.76	0.33	0.44
Salt	7.40	1.76	1.01	3.20	.76	.33	.44
Grain	13.80	3.28	1.88	3.30	.79	.34	.45
Coal	7.10	1.69	.97	3.00	.71	.30	.41
Iron	11.00	2.62	1.51	4.30	1.02	.44	.59
Zinc and lead	13.80	3.28	1.88	4.50	1.07	.46	.61
Phosphate	7.10	1.69	.97	3.20	.76	.33	.44
Mineral oils	13.80	3.28	1.88	4.50	1.07	.46	.61
General merchandise	29.70	7.07	4.06	5.50	1.31	.56	.75

HAMBURG-DRESDEN.

Articles.	Rail (460 kilometers, or 286 miles).			Water (565 kilometers, or 351 miles).			Per ton-mile, rail distance.
	Per ton.		Per ton-mile.	Per ton.		Per ton-mile.	
	Marks.		*Cents.*	*Marks.*		*Cents.*	*Cents.*
Sugar	28.80	$6.85	2.39	5.30	$1.26	0.36	0.44
Salt	11.30	2.69	.93	5.30	1.26	.36	.44
Grain	21.90	5.21	1.82	5.30	1.26	.36	.44
Coal	9.90	2.36	.83	5.20	1.24	.35	.43
Iron	17.30	4.12	1.44	5.50	1.31	.37	.45
Zinc and lead	21.90	5.21	1.82	5.50	1.31	.37	.45
Phosphate	9.90	2.36	.83	5.50	1.31	.37	.45
Mineral oils	21.90	5.21	1.82	5.50	1.31	.37	.45
General merchandise	43.70	10.40	3.46	7.50	1.78	.51	.62

HAMBURG-BRESLAU.

Article.	Rail (610 kilometers, or 379 miles).			Water (793 kilometers, or 493 miles).			Per ton-mile, rail distance.
	Per ton.		Per ton-mile.	Per ton.		Per ton-mile.	
	Marks.		*Cents.*	*Marks.*		*Cents.*	*Cents.*
Sugar	37.70	$8.97	2.37	6.00	$1.43	0.29	0.38
Salt	14.60	3.47	.91	6.50	1.55	.31	.41
Grain	28.60	6.81	1.80	6.50	1.55	.31	.41
Coal	12.00	2.86	.75	6.20	1.48	.30	.39
Iron	22.50	5.35	1.41	6.50	1.55	.31	.41
Zinc and lead	28.60	6.81	1.80	6.50	1.55	.31	.41
Phosphate	12.00	2.86	.75	6.50	1.55	.31	.41
Mineral oils	28.60	6.81	1.80	6.50	1.55	.31	.41
General merchandise	53.00	12.61	3.33	9.00	2.14	.43	.56

For the 10-year period 1897–1906 the average rail rate from Breslau to Hamburg for export sugar was $3.47 per ton, and if intended for domestic use, $6.81 in 10-ton lots, while the water rate on sugar regardless of where used was $1.35. Hence it appears that both the rail and water rates on this commodity given in the preceding table are considerably above the average.

The principal commodities shipped downstream on the Oder are sugar destined for Hamburg and coal for Berlin. The average water rate during the period 1903–1907 on coal from Breslau to Berlin was $0.766 per ton. From Kosel to Berlin it was $1.28. The following tables show the high, low and average water rates for the coal shipments on the Oder from Breslau and Kosel to Berlin. This traffic passes through the Spree-Oder Canal and pays a small toll. The traffic from Kosel, where the Oder is canalized, pays two tolls, which are included in the rates given. The rail rates on this coal traffic are somewhat lower than those on English coal from Hamburg, in order to permit the Silesian coal to compete on equal terms with the foreign product. In spite of this fact, as will be seen, the rail rates are considerably above the water rates.[1]

I.—*Coal rates from Breslau to Berlin via the Oder and connecting waterways.*

Year.	High.	Low.	Average.
	Per ton.	*Per ton.*	*Per ton.*
1903	$0.86	$0.59	$0.71
1904	1.30	.57	.90
1905	.98	.62	.76
1906	.88	.59	.71
1907	1.12	.59	.72

The exceptional rail rate on this coal if shipped in carload lots of not less than 10 tons is 0.745 cent per ton-mile with a terminal charge of 17 cents which for a distance of 205 miles amounts to $1.69 per ton.[2]

[1] Paul Goehts, op. cit., p. 148.

[2] Ibid., p. 149.

II.—*Coal rates from Kosel to Berlin via the Oder and connecting waterways.*

Year.	High.	Low.	Average.
	Per ton.	*Per ton.*	*Per ton.*
1903	$1.38	$1.17	$1.27
1904	1.57	1.14	1.36
1905	1.45	1.14	1.27
1906	1.36	1.12	1.24
1907	1.36	1.17	1.24

On this traffic the all rail route is in competition with the rail and water route via Kosel.

The exceptional rate on coal from the mines at Königshütte directly to Berlin, a distance of 309 miles, including terminal charges of 17 cents, is $2.37 per ton. To the water rate there must be added about 42 cents per ton to cover a rail haul of 40 miles from Königshütte to Kosel and charges for transshipment from rail to river barges.

The marked difference between rail and water rates on the three large German rivers has led to the formation of a number of large shipping combinations for the purpose of raising water rates which the competition of boatmen forces down to the no-profit level. The coal Kontor on the Rhine has been partially successful in its efforts to this end. On the Elbe there are several large combinations which own their own towing steamers and barges. An interesting combination was formed in 1904, known as the Privatschiffer-Transport-Genossenschaft, with headquarters at Magdeburg. It is an association composed of individual boatmen who have united in order to prevent the cutting of rates. It has a membership of more than one thousand, and controls some 1,200 vessels, with an aggregate capacity of 700,000 tons, and valued at about $6,000,000. In 1907 this association entered into a combination with two other leading shipping companies for the purpose of preventing competition. Thus far they have only been partially successful in raising water rates. One obstacle undoubtedly is the existence of strict municipal supervision over terminals so that new companies can enter the field at any time without fear of unfair competition.

Some of these large shipping corporations, especially on the Rhine, operate passenger as well as freight boats, and also because of the large differential between rail and water rates have been able to operate express steamers. The Berliner Lloyd, with headquarters at Berlin, maintains a daily express service between Hamburg, Breslau, Magdeburg, and a number of other ports. The United Elbe Navigation Company also operates an extensive express service between Hamburg and a large number of river ports.[1]

The wide margin which exists between rail and water rates has furnished one of the strongest arguments in the campaign which Prussia has waged for the levying of tolls on the free rivers.[2] The

[1] Cf. Edwin J. Clapp, The Port of Hamburg, p. 148.
[2] Cf. Peter's Schiffahrtsabgaben in Schriften des Vereins für Social-Politik, vol. 115-116.

amount of the toll proposed to be collected, it is stated, would be only a very small proportion of the existing differentials.

A comparison of the rail and water rates for different commodities in Belgium shows that the margin in favor of the waterways is not so great as is the case in Germany. The rail rate is rarely ever more than 40 per cent higher than the water rate, while on the German rivers it is often from 200 to 300 per cent higher. Except for the three ship canals, the waterways only accommodate 300-ton barges, and on all, except the two free rivers, tolls are charged which are sufficient to cover most of the maintenance charges.

The following table gives a comparison of freight rates by rail and by water between Antwerp and other centers:[1]

Route.	Railway.			Waterway.			
	Miles.	Rate per ton.	Rate per ton-mile.	Miles.	Rate per ton.	Rate per ton-mile.	Rate per ton-mile, rail distance.
			Mills.			*Mills.*	*Mills.*
Antwerp to Ghent[1]	32			54			
Coal and minerals		$0.59	18.4		$0.385	7.2	12.3
Cement		.745	23.2		.385	7.2	12.3
Antwerp to Courtrai[1]	60			99			
Coal and minerals		.85	14.2		.385	3.8	6.4
Cement		1.115	18.6		.385	3.8	6.4
Antwerp to Tournai[1]	79			108			
Coal and minerals		.915	11.6		.625	5.9	7.9
Cement		1.25	15.8		.625	5.9	7.9
Antwerp to Ath[1]	60			69			
Coal and minerals		.85	14.2		.575	8.4	9.6
Cement		1.115	18.6		.575	8.4	9.6
Antwerp to Brussels[1]	30			37			
Coal		.555	18.6		.43	11.6	14.3
Cement		.44	22.8		.735	20	24.5
Antwerp to Charleroi[2]	67			81			
Coal and minerals		.875	13		.96	11.8	14.3
Cement		1.18	17.6		.96	11.8	14.3
Antwerp to Liege[2]	74			95			
Coal and minerals		.90	12.2		.575	6	7.7
Cement		1.225	16.6		.575	6	7.7

[1] On rivers, free and canalized, upstream. [2] On canals.

In the table which follows, a list of 20 rates for coal transported by rail and by water between the same points in France is given. The average rate per ton-mile by rail is 9.3 mills and by water 4.5 mills, or about half. But the distance by water in France is generally very much longer than the rail distance, and hence the ton-mile rates are unduly low. If the rail distances are taken in computing these rates, as is done in the last column, the average rate per ton-mile by water for these 20 examples is 6.5 mills, or about 70 per cent of the average ton-mile rail rate.

[1] Lindley, p. 178.

Relative cost of the transportation of coal by rail and by water.[1]

Coal.		Distance—		Carriage cost of 1 ton—		Cost per ton-mile—		Per ton-mile, rail distance.
Coming from—	Bound to—	By rail.	By water.	By rail.	By water.	By rail.	By water.	
		Miles.	*Miles.*					
Antwerp	Douai	112	137	$1.235	$0.613	$0.0110	$0.0045	$0.0055
	Paris	230	351	1.940	1.664	.0084	.0047	.0072
	Corbeil	255	373	2.290	1.751	.0090	.0047	.0070
	Lyon	478	621	4.226	2.977	.0088	.0048	.0062
Charleroi	Reims	115	177	1.191	1.095	.0104	.0062	.0095
	Nancy	208	342	1.668	1.314	.0080	.0038	.0063
	Paris	168	236	1.480	1.314	.0088	.0056	.0079
	Rouen	208	298	1.524	1.314	.0073	.0044	.0063
	Dijon	292	534	2.505	1.795	.0086	.0033	.0061
Lens	St. Quentin	68	68	.815	.394	.0120	.0058	....
	Nancy	242	252	1.515	1.226	.0063	.0048	.0050
	Paris	130	227	1.174	.964	.0080	.0042	.0074
	Corbeil	158	249	1.629	1.051	.0103	.0042	.0066
	Elbeuf	140	273	1.121	.946	.0080	.0035	.0068
	Rouen	127	289	1.051	.964	.0083	.0033	.0076
	Lille	25	25	.332	.193	.0133	.0077	....
	Nevers	295	398	2.180	1.314	.0074	.0033	.0045
Rouen	Paris	87	149	.894	.569	.0103	.0038	.0065
	Corbeil	112	171	1.393	.613	.0124	.0036	.0055
	Lyon	413	547	3.485	1.664	.0084	.0030	.0040
Averages						.0093	.0045	.00647

[1] Collected for the National Waterways Commission by Maj. F. A. Mahan in 1911.

The following table shows the comparative rates for various articles transported between Havre and Paris, both by rail and via the Seine:[1]

Freight rates, Havre-Paris, rail and water.

Articles.	By rail.		By water.		
	Rate.	Per ton-mile.	Rate.	Per ton-mile.	Per ton-mile, rail distance.
		Cents.		*Cents.*	*Cents.*
Bacon	$4.41	3.10	$2.895	1.21	2.04
Beer, in casks	4.41	3.10	1.93	.83	1.36
Butter	7.35	5.11	2.895	1.21	2.04
Cement	1.64	1.15	1.64	.71	1.15
Cheese	2.895	2.03	2.509	1.08	1.77
Coal	1.35	.95	1.35	.58	.95
Dry goods	4.23	2.98	4.825	2.09	3.40
Fertilizers, in bags	1.93	1.35	1.93	.83	1.36
Flour	1.93	1.35	1.93	.83	1.36
Furniture, in cases or crates	8.86	6.24	4.246	1.83	3.00
Glassware, common	2.895	2.03	2.316	1.002	1.63
Grain	1.93	1.35	1.93	.83	1.36
Iron, bar	2.123	1.49	1.64	.71	1.15
Lumber	1.64	1.15	1.544	.66	1.09
Machinery, farm, in parts	2.316	1.63	2.123	.91	1.50
Machinery, other, cased	2.895	2.03	2.316	1.002	1.63
Molasses	1.93	1.35	1.93	.83	1.36
Potatoes	2.123	1.49	2.316	1.002	1.63
Shoes	5.98	4.21	4.246	1.83	3.00
Spades and shovels	2.895	2.03	2.316	1.002	1.63
Sugar	1.93	1.35	2.509	1.08	1.77
Window glass	1.93	1.35	2.123	.91	1.50
Wine, in casks	4.05	2.84	3.474	1.50	2.45

NOTE.—Distance by rail, 142 miles; by water, 231 miles. Upstream rates are given only. Weight is metric ton.

[1] National Waterways Commission Doc. No. 16, p. 71.

Slightly lower rates than these are given for carload lots by rail, and by water for 4 tons and over. Downstream rates differ only slightly from upstream and for a few articles only.

In the United States the only water routes which enjoy a considerable margin over competing rail routes are found on the Great Lakes and in the coastwise trade. On the inland rivers rail rates are usually somewhat above the water rates on the higher classes of freight, while on the lower classes in which competition is more severe the waterways, as a rule, are scarcely able to compete at all. The following table shows the average ton-mile rate on the traffic which passes through the canals at St. Marys Falls. In recent years this rate has been about one-tenth of the average ton-mile freight rate for all the railways of the United States and is less than one-third the ton-mile rates on coal shipments from the West Virginia and Kentucky mines to the Lake Erie ports, which are among the lowest coal rates found anywhere in the United States. In recent years the rate from most of these mines to the lake front has been 97 cents per ton for distances varying from 325 to 456 miles, or at an average rate of less than 3 mills per ton per mile.

Traffic statistics at St. Marys Falls Canals, including ton-miles and cost per ton-mile.

[Monthly Summary of Commerce and Finance, Dec., 1910 and 1911.]

Year.	Total freight carried (tons).	Average distance carried.	Total ton-miles.	Amount paid for transporting freight.	
				Total.	Per ton-mile (mills).
1890	9,041,213	797.2	7,207,299,415	$9,472,215	1.3
1895	15,062,580	830.0	12,502,548,892	14,238,758	1.14
1898	21,234,665	842.6	17,891,597,030	14,125,896	.79
1900	25,643,073	825.9	21,179,229,014	24,953,314	1.18
1903	34,674,437	835.6	28,974,660,408	26,727,735	.92
1905	44,270,680	833.3	36,892,797,973	31,420,585	.85
1907	58,217,214	828.3	48,221,465,547	38,457,345	.80
1909	57,895,149	809.0	46,812,929,345	36,291,948	.78
1910	62,363,218	840.0	52,405,535,136	38,710,904	.74

The great predominance of iron ore in this lake traffic on which rates have been continually declining is responsible in a large measure for the unusually low ton-mile rate given above. In the table following the rates on iron ore transported from the Lake Superior to the Lake Erie ports are given separately. Estimating the average length of haul at from 800 to 850 miles, it will be seen that in 1900 this traffic was carried at about 1 .mill per ton per mile, while in 1911 the average rate was less than 0.6 mill per ton per mile.

Lake freight rates on iron ore from ports named to Lake Erie ports.

[From annual report of Lake Carriers' Association, 1911, p. 170.]

Years.	Escanaba, per ton.	Marquette, per ton.	Ashland and other ports at head of Lake Superior, per ton.
1900	$0.85	$0.94	$1.05
1901	.62	.74	.84
1902	.59	.68	.76
1903	.63	.73	.83
1904	.54	.61	.70
1905	.60	.70	.76
1906	.60	.70	.75
1907	.60	.70	.75
1908	.50	.60	.65
1909	.50	.60	.65
1910	.55	.65	.70
1911	.45	.55	.60

Water transportation is in such a decadent condition on most of our rivers that there are few boat lines operating on regular schedules with published rates. The cheapest river transportation known in this country is found on the coal shipments from the Monongahela down the Ohio and Mississippi to New Orleans. The actual cost of transporting this coal is not known since these shipments are made by the mining companies themselves. Furthermore, this coal is not shipped down the river at regular intervals, but is collected in the upper Ohio and sent down in a large number of barges at one time, when the stage of the river is most favorable. Thus many of the lockages usually necessary are avoided and the labor cost is reduced to the minimum.

On the Mississippi River there are a few packet lines which publish their rates, but in general water rates are difficult to obtain. It appears that the steamboat lines on the Mississippi are able to compete with the railways only on the higher classes of freight. Aside from the Ohio River coal, sand and gravel taken from the river itself, and rafts of lumber, there is very little bulky freight conveyed by boat on the Mississippi. The table following gives a comparison of rail and water rates from St. Louis to the different points on the upper Mississippi for the four highest classes. The water rates are those charged by the Streckfus Steamboat Co., successors to the Diamond Jo Line. As will be seen, the differential is very small in comparison with that which the waterways enjoy in European countries. In fact it does not even measure the difference in the quality of service between the railways and boat lines to say nothing of the loading and unloading, insurance, and other charges with which the river traffic is burdened.

A comparison of rail and water rates on the Mississippi.

From St. Louis.		Class rates.			
		1. Cents per hundred-weight.	2. Cents per hundred-weight.	3. Cents per hundred-weight.	4. Cents per hundred-weight.
To Hannibal, Mo.	Boat line	26.5	21.5	17	12.5
	Rail	33	27	21	15.5
	Differential	6.5	5.5	4	3
To Quincy, Ill.	Boat line	28	22.5	17.5	12.5
	Rail	35	28	22	15.5
	Differential	7	5.5	4.5	3
To Keokuk, Iowa	Boat line	30	25	18	13
	Rail	37	31	23	16.5
	Differential	7	6	5	3.5
To Burlington, Iowa	Boat line	30	25	18	13.5
	Rail	39.6	32	24.8	18
	Differential	9.6	7	6.8	4.5
To Davenport, Iowa	Boat line	33	26	20	15
	Rail	41.5	33.4	25.9	20.8
	Differential	8.5	7.4	5.9	5.8
To Clinton, Iowa	Boat line	33	26	20	15
	Rail	42.8	34.7	27.1	21.7
	Differential	9.8	8.7	7.1	6.7
To Dubuque, Iowa	Boat line	33	26	20	15
	Rail	45.9	37.6	29.7	23
	Differential	12.9	11.6	9.7	8
To La Crosse, Wis.	Boat line	34	28	22	16
	Rail	49	42	33	23
	Differential	15	14	11	7
To Winona, Minn.	Boat line	34	28	22	16
	Rail	50	42	33	23
	Differential	16	14	11	7
To St. Paul, Minn.	Boat line	40	34	27	17
	Rail	63	52.5	42	26
	Differential	23	18.5	15	9

The Annual Report of the Chief of Engineers for 1910 published a considerable number of rates charged by the Diamond Jo Line steamers operating from St. Louis to various river points. From these schedules of rates the ton-mile rates were computed for five numbered and five lettered classes. These are given in the tables following. It would not be difficult to find in the United States a large number of rail rates for similar distances lower than any given in these lists. When the greater length of the water route, the additional transfer and insurance, and the other disadvantages are considered, it is not surprising that the railways have little difficulty in practically eliminating water transportation.

Ton-mile rates on the Mississippi River.[1]

RATES PER TON-MILE TO TYPICAL POINTS ABOVE ST. LOUIS BY DIAMOND JO LINE STEAMERS.

Between St. Louis and—	Distance.	Merchandise.				In carloads.					
		Class 1.	Class 2.	Class 3.	Class 4.	Class 5.	Class A.	Class B.	Class C.	Class D.	Class E.
	Miles.										
Alton, Ill	25	$0.192	$0.160	$0.120	$0.088	$0.076	$0.072	$0.064	$0.064	$0.052	$0.044
Louisiana, Mo	108	.044	.037	.028	.022	.018	.017	.015	.015	.012	.010
Hannibal, Mo	136	.039	.032	.026	.018	.014	.013	.012	.011	.010	.008
Quincy, Ill	155	.036	.035	.023	.016	.013	.012	.012	.010	.009	.008
Canton, Mo	170	.015	.029	.021	.015	.012	.012	.012	.009	.008	.007
Fort Madison, Iowa	213	.028	.023	.017	.012	.009	.009	.009	.0070	.0066	.0056
Burlington, Iowa	234	.026	.021	.015	.012	.009	.010	.009	.0077	.0064	.0056
Keithsburg, Ill	259	.025	.020	.015	.012	.009	.009	.007	.0061	.0058	.0054
Rock Island, Ill., and Davenport, Iowa	313	.021	.017	.013	.010	.008	.008	.006	.0051	.0048	.0045
Clinton, Iowa	349	.019	.015	.011	.009	.007	.007	.006	.0051	.0046	.0046
Dubuque, Iowa	412	.016	.013	.010	.007	.006	.006	.005	.0044	.0039	.0039
Cassville, Wis	439	.015	.013	.010	.007	.005	.007	.005	.0045	.0045	.0045
Winona, Minn	560	.012	.010	.008	.006	.004	.006	.004	.0036	.0036	.0036
Wabasha, Minn	596	.013	.011	.009	.006	.005	.006	.005	.0040	.0033	.0033
St. Paul, Minn	676	.012	.010	.008	.005	.004	.005	.004	.0035	.0030	.0030

RATES PER TON-MILE TO TYPICAL POINTS BELOW ST. LOUIS BY LEE LINE STEAMERS.

	Miles.										
Cairo, Ill	176	$0.028	$0.023	$0.020	$0.016	$0.011	$0.011	$0.010	......	......	......
Columbus, Ky	197	.030	.023	.018	.014	.014	.012	......	$0.010	......	......
Hickman, Ky	214	.028	.023	.021	.017	.014	.013	......	.009	......	......
New Madrid, Mo	252	.032	.023	.021	.017	.014	......	......	.015	......	......
Tiptonville, Tenn	268	.045	.037	.034	.030	.024	.018	......	.017	......	......
Gayoso, Mo	291	.033	.026	.023	.019	.016	......	......	.017	......	......
Barfield, Ark	318	.030	.024	.021	.017	.014	......	......	.015	......	......
Luxora and Osceola, Ark	341	.031	.024	.022	.018	.014	......	......	.014	......	......
Memphis, Tenn	421	.024	.018	.016	.013	.011	.009	.006	......	$0.0052	$0.0048
Helena, Ark	511	.023	.020	.018	.014	.011	.010	.008	......	......	......
Vicksburg, Miss	830	.014	.012	.011	.008	.007	.006	.005	......	......	......
On Arkansas River:											
Pine Bluff, Ark	508	.023	.020	.016	.012	.009	......	......	.010	......	......
Little Rock, Ark	575	.021	.017	.014	.010	.008	......	......	.009	......	......

[1] Annual Report of Chief of Engineers, 1910, vol. 2, p. 1769.

COMPARISON OF UNITED STATES RAIL AND GERMAN WATER RATES.

The statement has sometimes been made that the waterways of Europe could not withstand the competition of our railways or that the rates frequently charged on our railways are lower than the rates found on those waterways of Europe which carry the largest traffic.[1] If foreign railways were allowed the same freedom in making their rates that our railways enjoy, they would undoubtedly be able to take from the waterways a considerable portion of their present traffic. In fact, during the period of active competition they demonstrated their ability to do it. There are instances in France to-day where a railroad company, in return for some consideration, has secured from the Government the right to make rates low enough to prevent the competing waterways from increasing their traffic to any considerable extent. Our railways would doubtless be able to offer more severe competition than the foreign railways, because they are built to carry heavier loads; but with the same restrictions forced upon them they could accomplish little.

If the railways of the United States are carrying traffic at lower rates than the principal waterways of Europe, a comparison of their

[1] Report of the Chicago Harbor Commission, 1909, p. 234; also Samuel O. Dunn, The American Transportation Question, p. 197.

respective rates will disclose this fact. Such a comparison is somewhat difficult to make, inasmuch as the length of haul in European countries is much less than in the United States. Accordingly, in the following tables the maximum rates fixed by the Iowa and the Illinois State commissions have been used. These are about the normal rates for such distances, and considerable quantities of coal and grain are being shipped under these tariffs. In each comparison an interstate rate is also given. In some cases these are higher and in other cases lower than the rates fixed by the State commissions. The water rates used are only for coal and grain transported on the Rhine and Elbe in Germany. These are the cheapest water rates found in Europe, with the possible exception of the grain rates on the Volga in Russia. It will be seen by examining the tables that our railroad rates are considerably lower than the German rail rates which compete with the Rhine and Elbe, but in the majority of cases are at least double their water rates. If the comparison were extended to water rates in Belgium or France, it would doubtless be found that in many instances our rail rates were less than their water rates. But this certainly is not true for the Rhine, Elbe, and other large rivers of Europe.

Comparison of United States rail and European water rates.[1]

1.—COAL.

	Rail distance.	Rail rate.	Water rate.	Per cent water of rail rate.
RHINE.	*Miles.*	*Per ton.*[2]	*Per ton.*[2]	
Ruhrort to Mannheim	202.45	$1.88	$0.409	21.8
Iowa State rates	200–210	1.32		30.9
Illinois State rates	200–210	1.11		36.8
Hocking coal district to lake front	[3] 220	.85		48.1
Ruhrort to Strassburg	267.65	2.26	.726	32.1
Iowa State rates	260–270	1.44		50.4
Illinois State rates	260–270	1.21		60
Fairmount coal district to Lorain	[3] 274	.97		74.8
Ruhrort to Frankfort on the Main	176.14	1.64	.474	28.9
Iowa State rates	175–180	1.24		38.2
Illinois State rates	175–180	1.06		44.7
California, Pa., to Coshocton, Ohio (Pennsylvania R. R)	173	.95		50
ELBE.				
Hamburg to Magdeburg	156	1.50	.64	42.7
Iowa State rates	150–160	1.18		54.2
Illinois State rates	150–160	1.02		62.7
Pittsburgh No. 8 district to lake front	[3] 150	.88		72.7
Hamburg to Berlin	174	1.69	.71	42
Iowa State rates	170–175	1.225		57.9
Illinois State rates	170–175	1.05		67.6
West Newton, Pa., to Cleveland, Ohio (Baltimore & Ohio)	190	1.00		71
Hamburg to Breslau	370	2.86	1.48	51.8
Iowa State rates	370–380	1.66		89.1
Illinois State rates	360–380	1.37		108.0
Thacker coal district to Sandusky	[3] 365	.97		152.6
Hamburg to Dresden	286	2.36	1.24	52.5
Iowa State rates	280–290	1.48		83.8
Illinois State rates	280–290	1.24		100
Kanawha district to Toledo	[3] 325	.97		127.8

[1] The United States rail rates were obtained from the Interstate Commerce Commission and the Bureau of Railway Economics. They are all commodity rates in carload lots. The German rail and water rates are taken from the tables given above.
[2] The foreign rates are for the metric ton of 2,204 pounds, the American rates are for the short ton of 2,000 pounds, and hence should be increased by 10 per cent in order to be strictly comparable.
[3] Estimated.

Comparison of United States rail and European water rates.

2.—GRAIN.

	Rail distance.	Rail rate.	Water rate.	Per cent water of rail rate.
RHINE.	*Miles.*	*Per ton.*	*Per ton.*	
Rotterdam to Mannheim	298	$5.81	$0.626	10.8
Iowa State rates	290-300			
Wheat, flour, millet, and flaxseed		2.70		23.2
Corn, oats, barley		2.24		27.9
Illinois State rates	290-300			
Wheat		2.42		25.9
Other grains		2.18		28.7
Fremont, Iowa, to Chicago (Chicago, Burlington & Quincy R. R.)—Wheat	296.6	2.60		24.1
Rotterdam to Strasburg	362.66	5.71	1.102	19.3
Iowa State rates	360-370			
Wheat, flour, millet, and flaxseed		3.08		35.8
Corn, oats, barley		2.56		43
Illinois State rates	360-380			
Wheat		2.60		42.4
Other grains		2.36		46.7
Rochester, N. Y., to Harrisburg, Pa. (Pennsylvania R. R.)—Wheat	356	2.00		55.1
Rotterdam to Frankfort on the Main	282.56	4.36	.764	17.5
Iowa State rates	280-290			
Wheat, flour, millet		2.66		28.7
Corn, oats, barley		2.20		34.7
Illinois State rates	280-290			
Wheat		2.38		32.1
Other grains		2.16		35.4
Burnham, Pa., to New York City (Pennsylvania R. R.)—Wheat	267	2.00		38.2
ELBE.				
Hamburg to Magdeburg	156	2.97	.67	22.5
Iowa State rates	155-160			
Wheat, flour, millet, and flaxseed		1.96		34.2
Corn, oats, barley		1.62		41.3
Illinois State rates	155-160			
Wheat		1.90		35.3
Other grains		1.72		39
Neal, Kans., to Kansas City, Mo. (Missouri Pacific)—Wheat	150	2.00		33.5
Hamburg to Breslau	379	6.81	1.55	22.8
Iowa State rates	370-380			
Wheat, flour, millet, and flaxseed		3.14		49.4
Common barley		2.62		59.1
Illinois State rates	360-380			
Wheat		2.60		59.6
Other grain		2.37		65.4
Oakley, Kans., to Kansas City, Mo. (Union Pacific)—Wheat	377	2.90		53.5
Hamburg to Dresden	286	5.21	1.26	24.2
Iowa State rates	280-290			
Wheat, flour, millet, and flaxseed		2.66		47.4
Corn, oats, barley		2.20		57.3
Illinois State rates	280-290			
Wheat		2.38		53
Other grain		2.16		58.3
Rutledge, Mo., to Chicago (Atchison)—Wheat	287	2.40		52.5
Hamburg to Breslau	174	3.28	.79	24.1
Iowa State rates	170-175			
Wheat, flour, millet, and flaxseed		2.02		39.1
Corn, oats, barley		1.68		47
Illinois State rates	170-175			
Wheat		1.96		40.3
Other grain		1.78		44.4
Lewisburg, Pa., to Wilmington, Del. (Pennsylvania R. R.)—Wheat	185	2.00		39.5

The purpose of presenting the comparisons of rail and water rates of different countries given in this chapter has been to show that a wide margin in favor of the waterways has been an important reason for the phenomenal growth of water transportation. These comparisons should not be interpreted as showing the relative cost of transportation by rail and by water. This is an altogether different problem, and involves the consideration of a large number of factors which make exact conclusions difficult. The differential in favor of a waterway might be very considerable, and yet the actual cost of transportation, if all the elements are considered, might be greater than on a competing railway. Where, as in France, a differential of 20 per cent is frequently enforced for the protection of the waterway, it is readily seen that a comparison of rail and water rates affords no criterion as to the actual cost of transportation by rail and by water. The same is true for Germany and Belgium, where the rail rates are fixed by the State while the water lines are free to cut rates as they choose. The rail rates may cover all costs of maintenance and operation and yield a profit on the capital invested in right of way, road bed, terminals, and rolling stock, while the water rates, especially where the improvement and maintenance is carried on by the Government and no tolls are charged, may yield the boatmen little above their labor costs and a fair return upon the capital invested in equipment.

THE RELATIVE COST OF TRANSPORTATION BY RAIL AND BY WATER.

It is accepted as almost axiomatic that water transportation is cheaper than transportation by rail. The common assertion is that it is from five to six times as cheap. Although this is one of the most important questions relating to water transportation, it is the one that has been least investigated. And yet on this theory the improvement of inland waterways in all countries has been undertaken, and the United States is annually spending $30,000,000. If inland waterways can not afford cheaper transportation than railroads, then the sums spent for promoting navigation could be more profitably utilized for increasing the railway mileage and efficiency.

The belief that water transportation is cheaper than rail is sometimes based on three theoretical arguments: (1) The equipment necessary to carry a given load on the water is much less expensive than on rail; (2) the same amount of motive power can move five or six times the tonnage on water that it can on rails, because it encounters less resistance, and the tare or dead weight by water is much less; (3) the cost of maintenance of a waterway is much less than that of a railway. The comparative cost of roadbed and channel depends upon the physical characteristics in each case. Oceans, lakes, and large rivers need little improvement to accommodate a large traffic, while the cost per mile of improving small rivers or constructing canals may far exceed that of building a railway. For example, the cost of constructing the Dortmund-Ems Canal in Germany was $105,000 per mile. The cost of enlarging the Erie Canal is estimated at about $300,000 per mile. The estimated cost of the proposed 14-foot canal connecting the Ohio River near Pittsburgh with Lake Erie is about $600,000 per mile. In contrast, the average capitalization per mile of railway in this country is $62,657.

There are a number of considerations which affect the importance of these factors. The initial resistance on a waterway varies considerably with different circumstances, such as the physical characteristics of the waterway and the type and draft of boat. On the ocean or Great Lakes the freedom of the water displaced to dissipate itself from the path of the boat makes the initial resistance much less than in a narrow channel where the water must roll up in front. As regards the effect of the type of boat, the greater its capacity for carrying freight with a given draft, the greater will be the initial resistance. A canal barge of the usual type is much more difficult to tow than another boat of the same draft but with sharp prow and curved bottom.

The question of speed is rarely given sufficient consideration in a discussion of the relative value and cost of transportation by rail and by water. But it affects the comparison in at least three ways. In the first place, the greater speed possible by rail increases the value of service to the shipper, for which added value he is generally willing to pay a somewhat higher charge. A more rapid delivery of consignments is usually more valuable for the higher grades of freight than for the coarse, bulky commodities. The importance of speed to the shipper is shown by the fact that where, as sometimes happens, boat lines afford a quicker and more reliable means of transportation they are able to charge higher rates than the competing railways.

In the second place, the greater speed possible on a railroad results in the much greater utilization of a given equipment. It has been estimated, for instance, that a railroad car makes in a year eight times as many trips of a given length as a canal barge. This is due both to greater speed and to less delay during cold weather. The physical characteristics of a waterway are important in this connection. On larger bodies of water a speed approaching that possible on rails is obtainable, while on small streams and on canals the speed possible is far less than that by rail, not only because of the greater resistance but because of the damage which the wash would cause to the banks. Where locks must be passed the speed attainable on a canal or canalized river is further reduced. Thus it is apparent that where a given equipment may be used only at a rate of 3 or 4 miles an hour, it will return a much less income upon the investment than an equipment which may be moved from 12 to 15 miles an hour. Ordinarily this fact largely offsets the greater cost of rail equipment. In periods of congested traffic or where the railways are crowded with passenger traffic, as in some parts of Europe, the waterway is often the quicker means of transportation. In such cases the advantage of the railway as regards speed is nullified.

In the third place, speed affects the relative cost of propulsion. On a railroad an increase in speed results in no increase in resistance, except that of the air. The friction offered by the rails is fairly constant. On water an increase of speed results in a rapidly increasing resistance. According to the physical law of momentum, to double the speed it is necessary to quadruple the propelling or tractive power. Thus the saving in motive power of water transportation over rail diminishes as speed increases. Where, as on an artificial waterway, the initial resistance encountered by a boat is very large, a small increase of speed makes the motive power soon equal to that necessary for moving the same load by rail.

Another factor of special importance is the capacity which a given waterway will accommodate. It is a well-known fact that in water transportation a small increase in depth will result in a large increase in the capacity of a boat. Where a 6-foot depth will accommodate 300 to 600 ton barges, a 12-foot depth might accommodate boats with a capacity as large as 1,500 tons or even 2,000 tons. The larger the tonnage of a boat the less the cost of transportation per ton becomes. This is due mainly to saving in labor costs and in the duplication of propelling machinery. There is probably little saving in the actual fuel costs, because the resistance is approximately doubled by doubling the draft. This advantage of deeper-draft boats may be largely overcome by using barges in a tow. It has been estimated that the equipment necessary to move a given tonnage by this means costs little if any more than to move it in one boat carrying its own propelling power. The fuel cost would be no greater, while the labor cost might be somewhat increased. The extent to which the cost of transportation by water is less than by rail depends again upon the physical characteristics of the waterway considered. On the ocean and the Great Lakes the cost of transportation is undoubtedly considerably below that possible by rail. On the large rivers, such as the Rhine, which can accommodate boats of 1,800 tons capacity, it is probable that the cost is somewhat lower than is possible by rail, but on the smaller rivers and on canals the cost of transportation by water may often prove to be higher than by rail.

The amount of traffic available for transportation with a given equipment affects the cost of transportation by water in much the same way that it does by rail. In both cases there are certain fixed costs upon which interest should be paid, regardless of the amount of traffic moved, so that an increase of business with the same equipment results in a rapid decrease in cost per unit. When the waterway is a canal and intended to be self-supporting, the analogy is perfect, but the same principle should also apply to expenditures for the improvement of rivers. In determining the cost of transportation by water each ton should be charged with its proportion of the cost of improvement, even though in actual practice this expense is borne by the Government.

Although the equipment in water transportation costs less for a given amount of traffic than that necessary for transportation by rail, the adaptability of the equipment is much less, so that it is more difficult for it to earn as large a return upon the investment. In water transportation the unit of carriage is far greater than by rail. The average freight cars do not carry more than 30 or 40 tons, while in water transportation, since the cost becomes less as the unit of carriage increases, the tendency is to increase the capacity of the boats to the maximum permitted by the waterway. The larger the capacity of the boat the less adaptable it is to the varying quantities of traffic demanding transportation. The whole boat must be moved even if it is not fully loaded. In rail transportation the smaller unit makes it easier to adjust the equipment to the amount of traffic. While the idle cars represent an investment on which there must be a return, yet their maintenance is less when not in use, and the expense of hauling them is also eliminated.

In obtaining traffic a railroad has an advantage over a waterway, because its traffic is more diversified and can be obtained from many

sources. As already pointed out, the traffic of the waterway is necessarily confined to a comparatively few commodities. If these are not obtainable in large quantities so that boats can be loaded full without unnecessary delay, the cost per unit of moving the traffic that it does obtain will greatly increase. Because of the larger units of carriage on a waterway, it must necessarily transport most of its freight to large factories or other consumers. It would be unprofitable to deliver freight in small quantities among a lot of small consumers. On the Aire and Calder Navigation in England this difficulty has been obviated to some extent by hauling coal in compartment boats, sometimes called Tom Puddings. Each boat carries about 40 tons, and a large number are towed together in trains. Their adaptability is nearly as great as that of a railroad car.

It happens more often in water than in rail transportation that the equipment is carried empty in one direction. This is due to the smaller number of commodities which furnish the main business of the waterway. Where the great bulk of traffic is coal, the boats generally return empty or only partly loaded. Furthermore, a waterway can only be used for transportation for a portion of the year. Dry weather on the one hand and winter weather on the other prevent its use for navigation. On artificial waterways also the delays, due to breaks in the locks and other reasons, are much greater per year than the delays on a railway.

A frequent method of demonstrating that waterway transportation is cheaper than rail is by comparing the average cost per ton-mile on some waterway with that for all the railways in the United States. For instance, the average cost per ton-mile on the Great Lakes is about 0.8 mill, while for all the railways of the country it is about 7.6 mills. So it is often stated that transportation on the Great Lakes is 10 times as cheap as by rail. The average rate per ton-mile on the Erie Canal is about 2.45 mills. Comparing this with the average freight rate it is frequently stated that the cost of transportation on this canal is only about one-third of that by rail. But no such exact comparisons as these can be made for the reason that the rates compared do not include the same elements of cost. The average ton-mile rate on the Great Lakes only covers the bare cost of conveying the traffic, together with some return upon the equipment used. It contributes nothing to the large expenditures made by the Federal Government for improving the harbors and the connecting channels of the Great Lakes, which aggregate more than $60,000,000. Furthermore, the lake rate is based on an average haul of more than 800 miles for a few bulky commodities, such as iron ore, coal, and grain, which constitute more than 80 per cent of the total tonnage. The average railroad freight rate includes high-grade as well as low-grade freights, and also all local as well as long-distance traffic. If the average rail rate on a few bulky commodities for a haul of 800 miles could be obtained, it would doubtless be much less than the average rail rate for all the freight transported in the country. While there is no doubt that transportation on the Great Lakes, including all additional expenses with which the traffic should be charged, is much cheaper than by rail, an exact ratio between the two is practically impossible to determine.

The average cost of transportation on the Erie Canal includes only the bare cost of conveying this traffic, plus a small return on the

equipment used; it contributes nothing for maintenance, nor does it make any return upon the capital expended for the construction and enlargement of the canal. Both of these expenses are paid by the State of New York. It has been conservatively estimated that if the canal traffic were charged with a toll sufficient to cover these additional expenses the rate per ton per mile would amount to about 8.61 mills.[1] The average ton-mile rate for similar commodities, especially on the railways in New York State, is probably not more than 5 or 6 mills per ton per mile. In the case of the Erie Canal, however, it is a question whether in estimating the actual cost the traffic should be charged with anything more than the cost of maintenance and operation, since the tolls collected on the canal up to 1882 were sufficient to amortize the cost of construction and enlargement and in addition to return a considerable profit to the State. The purpose of using these two familiar illustrations, the Great Lakes and the Erie Canal, is only to point out the difficulty of making any exact comparison between the cost of transportation by rail and by water. Whether water traffic should actually be charged with all the expenses incurred for aiding navigation or whether these should be met in whole or in part by taxation is a question of public policy.

Any comparison between the cost of transportation by rail and by water will be of value only when the two rates include similar elements of cost. Few such comparisons have ever been made. Furthermore, the cost of transportation on large bodies of water, such as the Great Lakes, where an enormous traffic in bulky freights is being transported, is no criterion of what the cost of transportation is on some other waterway. The problem is different in each case and is affected by a number of factors, of which the depth of channel is only one.

The cost of water transportation, even on the smaller rivers or canals, might in many instances be considerably less than by rail if ideal conditions prevailed, but in actual practice there are so many offsetting influences that the greater apparent economy is only occasionally realized. The committee on canals in New York State in 1899 estimated that freight could be conveyed on the Erie Canal for 1.75 mills per ton-mile even after making allowance for the fact that a boat could only make seven trips during the season of navigation, and traveled one way with only a third of a load.[2] As a matter of practice, the cost has averaged more than 2.45 mills, or an increase of 40 per cent, due to the lack of ideal conditions. The cost of transporting coal down the Ohio and Mississippi as it is now being carried on is considerably less than is possible on a railroad, but there are not many instances in the United States where conditions so favorable for cheap river transportation prevail. It is quite probable that on most of our rivers the actual cost of transportation is higher than by rail, because there is only a small amount of miscellaneous freight available for transportation. To realize the economy which might be attained a large tonnage of some bulky commodity such as coal is necessary, the movement of which depends upon favorable economic conditions.

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[1] Bulletin No. 21, Bureau of Railway Economics. [2] P. 57.

VII.

A Waterway Policy.

Some of the economic factors which heretofore have been unfavorable to the development of water transportation in the United States are gradually changing. Population is increasing rapidly. The average increase for the past decade has been more than 1,590,000 a year. The industrial development of the country is also making rapid strides. During the last decade the value of agricultural products has doubled, and the quantity of a number of manufactured commodities has also increased more than twofold.

The movement of traffic has increased entirely out of proportion to the increase in transportation facilities. During the period 1900 to 1910 the railway mileage increased 35.9 per cent, the number of locomotives increased 56.5 per cent, the number of freight cars 56.4 per cent, while the increase in the freight ton mileage was 80.1 per cent. Previous to this period the development of transportation facilities had increased more rapidly than the demand for them, and the railways made special effort to secure traffic of any kind for their idle equipment, even at very low rates. But with the rapid expansion which took place between the years 1904 and 1907 all the surplus capacity of the railways was soon exhausted, and a congestion of traffic ensued. During the succeeding four years of quieter business the capacity of the railways has not been so severely taxed, but with the next period of expansion there is strong probability of a worse congestion of traffic than occurred before. The knowledge of this fact has made some of the leading railway officials more favorably disposed toward competing waterways, which offer a means of relief from the heavier and less profitable traffic, and it would not be surprising if in time considerable use of the rivers was made by the railways for the transportation of their low-grade freight. The rapid development of the country and the great increase in land values make the construction of new railway lines enormously expensive, and the lack of available space often makes it absolutely impossible to enlarge terminal facilities at any cost.

Another factor favorable to the waterways is that the tendency of rail rates in recent years has been upward rather than downward. It is not probable that rail rates will ever be much lower than at present. The steady decline in rates, which culminated in 1900, was brought about by cutting down grades, straightening roadbeds, and using heavier rails. The improvements made possible the use of more powerful locomotives and longer trains. On many roads these improvements have been largely completed, and further economies of this nature can only be secured by widening the gauge of the track. If this were done for all the railways of the country it would mean an expenditure of many billions of dollars, and it would be very doubtful if the saving to be effected by such an improvement would be commensurate with the cost. Some further economies may be secured by perfecting the organization and adopting more scientific methods in railway operation, but these will not be sufficient to permit of much reduction in rates. Furthermore, the elimination of competition between railways and the more harmonious relations which now exist have removed the main incentive for effecting econ-

omies and reducing rates. The increasing power of the Federal Government over railway rates also has a tendency, as in England and France, to reduce their elasticity. Railways naturally hesitate to lower their rates when they know that it will be difficult to raise them again.

These factors indicate that in the course of time those waterways which are favorably situated will undoubtedly have a large increase in traffic, provided the Government adopts a definite policy for their improvement and protection, but unless such a policy is adopted, a marked improvement in water-borne commerce can hardly be expected.

Much emphasis has been laid in recent years upon the necessity of adopting a comprehensive waterway policy. The Inland Waterways Commission, in its preliminary report, recommended that the improvement of waterways for the promotion of navigation should also take account of the purification of the waters, the development of power, the control of floods, the reclamation of lands by irrigation and drainage, and all other uses of the waters, or benefits to be derived from their control.

Thus far in this country rivers have been improved almost exclusively for aiding navigation, because the constitutional power of the Federal Government to undertake improvements for this purpose is much more certain than for the other purposes which benefit, to a greater extent, local or private interests. Another reason is that where a country is sparsely settled the property adjacent to a river is usually of little value, and the losses from floods or bank erosion are accordingly small. But as a country becomes more thickly settled, the losses due to the lack of proper control of streams mount up with great rapidity.

In the preceding sections it has been pointed out that the traffic possibilities of streams vary greatly. Only those which combine in largest degree all the favorable factors will develop a large traffic. In every country there are a few waterways with exceptional advantages whose commerce far exceeds that of the other streams less favorably situated. A sound policy of improving waterways should take this fact into consideration as well as the relative importance of the different uses of a stream, and carry out its improvement accordingly. There are numerous instances in the United States where costly improvements have been carried out for the purpose of promoting navigation in streams, which in time, if not already, will have a far greater value for the development of water power or some other use. Often the improvements made for navigation have rendered the river less useful for these other purposes. In canalizing a stream for aiding navigation it is usually more economical to build a number of dams of less height, while for power development fewer dams with greater height are desirable. Every stream should therefore be studied with a view to all its possibilities, and improved accordingly. One use should not be developed to the exclusion of all others, but the combination of uses which will result in the greatest benefits should be promoted.

Appropriations made for promoting navigation should bear some relation to the benefits to be derived. It is unwise to make a $1,000,000 improvement where only a few thousand tons of traffic are in sight. To ascertain the proper relation a much more careful

examination of the traffic possibilities of every stream should be made before its improvement is undertaken. A classification of all existing projects is also necessary, so that those whose improvement is most needed and which will most certainly result in a prompt increase in traffic should be undertaken and completed first. There is little justification for making improvements to aid navigation when they are not needed. Instead of digging rivers deeper, it would be more advisable in most cases to secure a uniform depth and dependable channel over as long a distance as possible and to adapt the type of boat to the depth obtained. This has been the practice in European countries, where most of the inland water-borne traffic is carried on a depth of 6 feet or less. Furthermore, as already stated, cheap water transportation depends upon a number of factors aside from the depth of channel.

Various plans have been suggested for securing the better administration and coordination of waterway improvements in this country. The Inland Waterways Commission recommended that a permanent commission be established for this purpose, and there is now a bill in Congress, introduced by Senator Newlands, of Nevada, a member of the Inland Waterways Commission, which, among other things, provides for the creation of such a board, its membership consisting of the Chief of Engineers of the United States Army, the Director of the United States Geological Survey, the Chief Forester, the Director of the Reclamation Service, the Chief of the Bureau of Plant Industry of the Department of Agriculture, the Secretary of the Smithsonian Institution, one civil engineer, one sanitary engineer, and one hydro-electric engineer.[1]

Another plan which is suggested by German practice is that there should be established a number of waterway boards, such as the Mississippi River Commission, each of which shall have full supervision over a particular stream. The membership of these boards should be varied, in accordance with the different uses which are to be developed in the improvement of the stream, and, if necessary, the work of these different river commissions might be coordinated by a central body. But, after all, the particular administrative machinery by which the work is to be carried on is not so important as that sound principles be adopted for future waterway improvements.

One of the worst difficulties that will be encountered in carrying out a comprehensive policy of waterway improvements is to secure the cooperation of States and localities in providing adequate terminals and in bearing their share of the cost of improvements that are largely for local benefit. There appears to be no way by which the Federal Government can legally compel localities and private interests to contribute their share of the expense. Such participation must necessarily be voluntary. But the plan might be adopted by the Federal Government of making river and harbor improvements only where the States and localities agree to provide terminals and contribute their share of the cost.

The United States must also adopt a definite policy regarding the relations between railways and waterways before any marked improvement in river transportation can be looked for. Such a policy must be based upon the idea that the purpose of improving waterways is to secure additional means of transportation and not to

[1] S. 122, 62d Cong., 1st sess.

reduce or regulate railway rates. Experience has demonstrated that waterways can not be relied upon as the great cheapeners and regulators of railway rates which they once were supposed to be. The railways have demonstrated their ability to control or crush out water competition, unless prevented by proper legislation. The reduction of railway rates at river points results in a maladjustment which is not beneficial to the country as a whole. No European country uses its waterways to control railway rates. That is accomplished by the proper administrative bureau of the government, and the waterways are improved with the idea of securing additional means of transportation. Until we adopt the same policy in this country the money expended for the promotion of navigation will result in little benefit. The waterways can not be used at the same time as means of transportation and as a regulator of railway rates. One use necessarily eliminates the other. If railway rates are reduced, the waterways lose their traffic, the capital invested in shipping is withdrawn, the equipment is allowed to deteriorate, and the additional means of transportation is lost to the public when a congestion of traffic occurs and the rivers are especially needed for the movement of freight.

A constructive policy for the protection of the waterways against railway competition must prevent the cutting of rates by railways, must remove any undue advantage which the railways may secure from the ownership or control of boat lines and terminal facilities, and, in the third place, must facilitate in every way possible the ready transfer of traffic from one to the other. Where, as in several European countries, the railways are owned by the government, the problem of affording such protection is not very difficult, but in the United States, where the railways are owned and operated by private corporations, the carrying out of this policy is a most difficult problem. It can only be done by increasing the power of the Interstate Commerce Commission over the making of railway rates and over the affairs of water carriers, and by greater activity on the part of States and municipalities in providing and controlling terminal facilities. The success of water transportation, as has been demonstrated, depends upon the differential which it enjoys over railroad rates. If the Government were to guarantee boat lines a certain differential, as is done in France, an increase in water-borne traffic would be certain to result. The main problem in this connection is whether the cost of transportation by a water route is enough cheaper than that by rail to warrant the granting of a certain differential in its favor. If such is not the case, the cost of transportation both by rail and water would be increased by such a policy. Evidently it would be unwise to lay down a fast rule for the protection of waterways, but a discretionary power might be exercised, as in France, in the case of certain waterways which are especially needed for transportation.

The rapid increase in the ownership and control of railways over boat lines calls for immediate regulation, so that the advantage derived may not be used to eliminate competitors and to raise water rates. As has already been stated, two widely different policies for the control of this situation are now before Congress. One would absolutely prevent railways from owning or controlling any boat line with which they were in competition; the other would give the Interstate Commerce Commission such control over the activities of

railway-owned boat lines that the public would be protected against the abuses which might arise. The latter policy is constructive, while the former is destructive and overlooks the benefit which we are striving to secure, namely, cheaper transportation. The main question with the public should be not so much who furnishes the transportation as that it should be adequate and cheap. If the latter policy is pursued, it will mean an increase of transfer traffic between the railways and waterways which otherwise could not be developed. The railways have the capital to invest in water transportation, and they have the traffic to exchange with water carriers. To prevent their participation in water transportation would be to force more of the traffic to go by rail.

It is desirable in the interest of the public that joint rail and water routes should be established wherever possible. To secure them it is necessary to establish physical connection between the railways and waterways and to remove all obstacles to the exchange of freight. As has been pointed out, the transfer of freight between the two agencies of transportation will be largest where self-interest is involved. Hence if railways are allowed to own or control boat lines, the exchange of freight will preferably be with their own lines, but it would often be of benefit to the public if railways could be forced to exchange freight with independent companies. To accomplish this the Interstate Commerce Commission should be empowered to establish such joint routes where they would be of benefit to the public and should be given such control over the rates that the railways could not impose obstacles to the development of transfer freight. Shippers could then choose the cheaper rail and water route if they desired; but the establishment of such combination rail and water routes should be discretionary with the Interstate Commerce Commission, for it obviously would be unfair to make railroads prorate with every boat line that desired such a privilege. Unless the boat line was a responsible company the railroad would have no assurance of being able to collect from it the division of through rates which might be agreed upon or of holding it liable for damages that might result to the freight exchanged.

The problem of protecting the waterways against railroad competition is a most difficult one and European experience helps little to a correct solution. But manifestly a definite policy must be determined upon before the extensive improvement of waterways is undertaken, for it is unsound economically to expend public funds without reasonable assurance of a commensurate return.

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